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DOD AMMUNITION AND EXPLOSIVES SAFETY STANDARDS

JANUARY 1978

DEPARTMENT OF DEFENSE
OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE
(MANPOWER, RESERVE AFFAIRS & LOGISTICS)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Establishes uniform safety standards and policies for development, manufacturing, testing, transportation, handling, storage, maintenance, and demilitarization of ammunition and explosives facilities.

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FOREWORD

These standards are issued under the authority of Title 10 USC 172 and Department of Defense Directive 5154.4, "The Department of Defense Explosives Safety Board," January 24, 1978. They establish uniform safety standards and policies for development, manufacturing, testing, transportation, handling, storage, maintenance, and demilitarization of ammunition and explosives facilities. Questions on interpretations and recommendations for amendments to these standards may be submitted to the Chairman, Department of Defense Explosives Safety Board, 2461 Eisenhower Avenue, Alexandria, VA 22331.

Effective immediately, these standards supersede and cancel DoD Standard 5154.4S, March 1976 and Interim Changes 2-1 through 2-5 thereto.

Perry J. Fliakas
Deputy Assistant Secretary of Defense
(Installations and Housing)

DEPARTMENT OF DEFENSE EXPLOSIVES SAFETY BOARD
2461 EISENHOWER AVENUE
ALEXANDRIA, VIRGINIA 22331

Interim Change 1
DoD 5154.4S

29 August 1979

DOD AMMUNITION AND EXPLOSIVES SAFETY STANDARDS

DoD 5154.4S, January 1978 is changed as follows:

1. Pen and Ink changes:

Page	Paragraph	Line	Action to Take
iv	Chapter 10		Change "Reserved" to "Real Property Contaminated with Ammunition and Explosives"
3-2	3-2B6	7	Change last sentence to "The distance required to protect from fragments in credible accident situations, however, will be established in accordance with the principles in paragraph 5-2F."
4-2	4-4D2	6	Add "without two or more safing features."
4-2	4-4D4	10	Change the last line to "torpedo warheads and fuzes with two or more safing features."
7-3	7-6B1b(1)	3	Change "paragraph 7-3C3" to "paragraph 7-3C"

2. Page changes:

Remove	Insert
Page (undated)	Page (dated 29 August 1979)
2-3 thru 2-6	2-3 thru 2-6
4-3 and 4-4	4-3 and 4-4
5-1 and 5-2	5-1 and 5-2
5-5 and 5-6	5-5 and 5-6
5-11 thru 5-14	5-11 thru 5-14
	10-1 thru 10-3

3. Effective date and Implementation. This interim change is effective immediately and will be reflected in a forthcoming permanent change. A copy of the implementing document shall be furnished the DoD Explosives Safety Board.

DEPARTMENT OF DEFENSE EXPLOSIVES SAFETY BOARD
2461 EISENHOWER AVENUE
ALEXANDRIA, VIRGINIA 22331

DDESB-KT

Interim Change 2
DoD 5154.4S

DoD
Ammunition and Explosives
Safety Standards

DoD 5154.4S, January 1978 is changed as follows:

1. Page changes:

Remove	Insert
Page	Page
2-1 thru 2-3	2-1 thru 2-3
3-1 thru 3-4	3-1 thru 3-4.5
3-9 thru 3-12	3-9 thru 3-12
5-2 thru 5-4	5-2 thru 5-4
8-3 thru 8-6	8-3 thru 8-6
9-1 and 9-2	9-1 and 9-2

2. Effective date and implementation. This interim change is effective immediately and will be reflected in a forthcoming permanent change. A copy of the implementing document shall be furnished the DoD Explosives Safety Board.

3. Additional copies. If additional copies of this Interim Change are needed, they must be reproduced locally.

ALTON W. POWELL
Colonel, USAF
Chairman

DEPARTMENT OF DEFENSE EXPLOSIVES SAFETY BOARD
2461 EISENHOWER AVENUE
ALEXANDRIA, VIRGINIA 22331

Interim Change 3
DoD 5154.4S

26 January 1982

DoD
AMMUNITION AND EXPLOSIVES
SAFETY STANDARDS

DoD 5154.4S, January 1978 is changed as follows:

1. Pen and ink change, page iv, add:

Chapter 13 - Personnel Protection 13-1

2. Pages changes:

Insert pages 13-1 and 13-2

3. Effective date and implementation. This interim change is effective immediately and will be reflected in a forthcoming permanent change. A copy of the implementing document shall be furnished the DoD Explosives Safety Board.

4. Additional copies. If additional copies of this Interim change are needed, they must be reproduced locally.

ALTON W. POWELL
Colonel, USAF
Chairman

DEPARTMENT OF DEFENSE EXPLOSIVES SAFETY BOARD
2461 EISENHOWER AVENUE
ALEXANDRIA, VIRGINIA 22331

DDESB-K

20 August 1982

Interim Change 4
DoD 5154.4S

DoD
Ammunition and Explosives
Safety Standards

DoD 5154.4S, January 1978 is changed as follows:

1. Page changes:

Remove	Insert
Page	Page
2-1 thru 2-6	2-1 thru 2-9
3-1	3-1
3-4 thru 3-8	3-4 thru 3-8
3-11 thru 3-13	3-11 thru 3-14
4-1 thru 4-4	4-1 thru 4-12
5-2 thru 5-5	5-2 thru 5-5
5-7 thru 5-8	5-7 thru 5-8.1
5-12 thru 5-17	5-12 thru 5-15
6-3	6-3 and 6-4
9-1 thru 9-3	9-1 thru 9-4
	14-1 thru 14-25

2. Effective date and implementation. This interim change is effective immediately and will be reflected in a forthcoming permanent change. A copy of the implementing document shall be furnished the DoD Explosives Safety Board.

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CHAPTER 1

INTRODUCTION

1-1. Authority

Publication and use of these standards are authorized by Department of Defense Directive 5154.4, "The Department of Defense Explosives Safety Board," January 24, 1978.

1-2. Purpose

This publication sets forth the Department of Defense ammunition and explosives safety standards and policies for:

A. Development, manufacturing, testing, transportation, handling, storage, maintenance, and demilitarization or disposal of ammunition and explosives.

B. Determination of hazard characteristics and assignment of uniform classifications to items of ammunition or explosives producing similar hazards which influence handling, storage, and transportation.

C. Construction and siting of ammunition and explosives facilities.

D. Siting of facilities for activities not involving ammunition and explosives which would be exposed to such hazards if improperly located.

1-3. Applicability

The provisions of these standards and policies apply to the Military Departments and Defense Agencies (hereinafter referred to collectively as "DoD Components").

1-4. Scope

A. The ammunition and explosives safety standards contained herein are minimum safety standards and govern the separation of explosives facilities within the boundaries of Department of Defense establishments. They also govern the locations of these facilities with respect to inhabited buildings, public traffic routes, airfields (heliports/seadromes), etc., inside and outside the boundaries of DoD establishments. These standards will also govern all construction planning started after the date of this publication

B. Inability to comply with these standards for strategic or other compelling reasons will require a specific waiver or exemption by the DoD Component concerned.

C. Deviations from these ammunition and explosives safety standards may be allowed:

1. Where facilities have already been constructed, or when approved for construction under plans which were developed prior to the date of this publication.

2. Where existing facilities do not comply with these standards and when the current hazard is not greater than that assumed for their original use or for those facilities in an advanced state of planning on the effective date of these standards. These deviations will be allowed for the balance of their useful lives when it can be clearly demonstrated that redesign or modification is not feasible, or that the quantity of explosives, propellants, or chemical agents for reasons of operational necessity cannot be reduced.

3. For fixed and completely assembled weapons systems, such as ICBM's, or other situations which upon analysis by the DoD Component concerned and the Department of Defense Explosives Safety Board are determined to provide the required degree of safety through use of protective construction or other specialized safety features.

D. Appropriate documentation will be maintained by each DoD Component, respectively, for each waiver, exemption, or other deviation from these standards in order that responsible officials may be kept aware of the existence of such deviations and can adequately assess the risk being accepted and the corrective measures being planned.

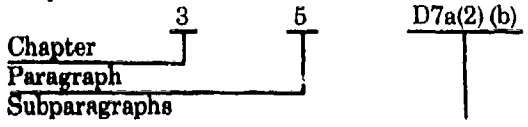
1-5. System Maintenance of these Standards

A. *Organization and Numbering.* These standards are organized into chapters. Each chapter is further subdivided into paragraphs and subparagraphs as appropriate. Special purpose data elements and illustrations are contained in figures and

tables in each chapter. Numbering is as follows:

1. *Chapters and Paragraphs.* The chapter and paragraph numbering scheme identifies the appropriate chapter followed by the applicable paragraph number within the chapter. Subparagraphs are indicated by uppercase Roman letters and Arabic numerals followed by lowercase letters and parenthesized numerals and letters:

Example: 3-5D7a(2)(b).



2. *Pages.* Pages are numbered consecutively in a separate series for each chapter. Each page number will follow the chapter number; e.g., 5-3 (Chapter 5, page 3).

3. *Figures and Tables.* Figures and tables are numbered consecutively in a separate series for each chapter. Each figure or table will contain the applicable paragraph, plus a decimal number; e.g., Figure 5-6.1 (Paragraph 5-6, Figure 1).

B. *Submission of Proposed Changes.*

1. Recommendations for revisions may be forwarded to the Chairman, Department of Defense Explosives Safety Board (DDESB).

2. Upon approval the proposed revision will be forwarded by the Chairman, DDESB to the ASD (MRA&L) or his designee for approval and publication.

C. *Publication of Changes.*

1. *Formal Changes.* Formal changes will be numbered consecutively and issued as full-page insertions to these standards. These changes will indicate the change number and effective date on each revised page. When it is necessary to supplement page changes with explanatory information, such explanation will be contained in the cover letter. Paragraphs that are modified or added will be indicated by a solid line on the outer margin of the page adjacent to the revision.

2. *Interim Changes.* When it is necessary to disseminate modifications to these standards more expeditiously, the Chairman, DDESB will distribute interim changes. However, prior to distribution, approval of the modifications will be obtained from the voting members of the DDESB. Interim changes may contain pen and ink changes as well as full page insertions and such changes will be numbered to indicate the formal change in which they will appear and numbered consecutively within that change. Example: Interim Change 1-3 is the third change designated to appear in the Formal Change 1. When there are sufficient Interim Changes to justify formal printing, they will be consolidated and published as a Formal Change to these standards. Interim changes are cancelled on publication of the formal change.

CHAPTER 2

EXPLANATION OF TERMS

Explanation of Terms

The following are descriptions of terms and phrases commonly used in conjunction with ammunition, explosives, and other dangerous materials. These are listed to provide a degree of uniformity of description in the use of technical information throughout these standards.

Aboveground Magazines

Any type of magazine abovegrade other than standard or non-standard earth-covered types of magazines.

Action Level

One-half of the exposure limit for a chemical agent averaged over an eight-hour work shift.

Administration Area

The area in which are located administrative buildings which function for the installation as a whole, excluding those offices located near and directly serving components of explosives storage and operating areas.

Aircraft Parking Area

Any area set aside for parking aircraft not containing explosives.

Aircraft Passenger Transport Operations

Passenger transport operations are defined as follows only for the purpose of applying explosives quantity-distance tables: Passenger transport traffic involving military dependents and civilians other than those employed by or working directly for DoD Components. The following are not considered "passenger transport operations."

A. Infrequent flights of base and command administrative aircraft that may, on occasion, provide some "space available" travel to authorized personnel.

B. Travel of Civil Service personnel employed by any DoD echelon.

C. Travel of such personnel as contractor or technical representatives traveling to or from direct support assignments at DoD installations.

Ammunition and Explosives

As used herein ammunition and explosives includes (but is not necessarily limited to) all items of ammunition; propellants, liquid and solid; high and low explosives; guided missiles; warheads; devices; pyrotechnics; chemical agents; components thereof, and substances associated therewith presenting real or potential hazards to life and property.

Ammunition and Explosives Aircraft Cargo Area

Any area specifically designated for:

A. Aircraft loading or unloading of transportation configured ammunition and explosives.

B. Parking aircraft loaded with transportation configured ammunition and explosives.

Ammunition and Explosives Area

An area specifically designated and set aside from other portions of an installation for the development, manufacture, testing, maintenance, storage, or handling of ammunition and explosives.

Anchorages

A. Scuttling Site. An area of water specifically designated for positioning a ship for its flooding or sinking under emergency situations.

B. Explosives Anchorage. An area of water specifically designated for loading and unloading vessels and for anchoring vessels carrying a cargo of ammunition and explosives.

Auxiliary Building

Any building accessory to or maintained and operated to serve an operating building, line, plant, or pier area. Explosive materials are not present in an auxiliary building. Examples: Power plants and change houses, paint and solvent lockers, and similar facilities.

Barricade

An intervening barrier, natural or artificial, of such type, size, and construction as to limit in a prescribed manner the effect of an explosion on nearby buildings or exposures.

Blast Impulse

The product of the overpressure from the blast wave of an explosion and the time during which it acts at a given point (i.e., the area under the positive phase of the overpressure vs time curve).

Blast Overpressure

The pressure, exceeding the ambient pressure, manifested in the shock wave of an explosion.

Cavern Storage Site

A natural cavern or former mining excavation adapted for the storage of ammunition and explosives.

Ceiling Value

The concentration of chemical agent that must not be exceeded for any period of time.

Chamber Interval

The distance between the natural walls of adjacent underground storage sites.

Chamber Storage Site

An excavated chamber or a series of excavated chambers especially suited to the storage of ammunition and explosives. A cavern may be subdivided or otherwise structurally modified for use as a chamber storage site.

Chemical Agent

A substance which is intended for military use with lethal or incapacitating effects upon man thru its chemical properties. Excluded from chemical agents for purposes of this standard are riot control agents, chemical herbicides, smoke and flame-producing items, and individual disassociated components of chemical agent ammunition.

Classification Yard

A railroad yard used for receiving, dispatching, classifying, and switching of cars.

Combat Aircraft Parking Area

Any area specifically designated for:

A. Aircraft loading or unloading of combat configured munitions.

B. Parking aircraft loaded with combat configured munitions.

Compatibility

Ammunition or explosives are considered compatible if they may be stored or transported together without significantly increasing either the probability of an accident or, for a given quantity, the magnitude of the effects of such an accident.

Connected-Chamber Storage Site

A chamber storage site consisting of two or more chambers connected by ducts or passageways. Such chambers may be at the ends of branch tunnels off a main passageway.

Controlling Authority

The term "controlling authority" as used in these standards refers to the headquarters of the DoD Component concerned.

Deflagration

A rapid chemical reaction in which the output of heat is sufficient to enable the reaction to proceed and be accelerated without input of heat from another source. Deflagration is a surface phenomenon with the reaction products flowing away from the unreacted material along the surface at subsonic velocity. The effect of a true deflagration under confinement is an explosion. Confinement of the reaction increases pressure, rate of reaction and temperature, and may cause transition into a detonation.

Detonation

A violent chemical reaction within a chemical compound or mechanical mixture evolving heat and pressure. A detonation is a reaction which proceeds through the reacted material toward the unreacted material at a supersonic velocity. The result of the chemical reaction is exertion of extremely high pressure on the surrounding medium forming a propagating shock wave which is originally of supersonic velocity. A detonation, when the material is located on or near the surface of the ground, is normally characterized by a crater.

Dividing Wall

A wall designed to prevent, control, or delay propagation of an explosion between quantities of explosives on opposite sides of the wall.

Dolphin

A mooring post or posts on a wharf or quay.

Engineering Controls

Regulation of facility operations through the use of prudent engineering principles; i.e., facility design, operational sequencing, equipment selection and process limitations.

Exemption

A relatively long term exception to an otherwise mandatory requirement of these standards. Exemptions may be granted by law, by Congressional resolution, or by a finding and determination by the Secretary or Deputy Secretary of Defense or by a Secretary or Under Secretary of a Military Department. Exemptions (except those established by Congressional action) shall be granted only when immediate corrective measures are wholly impractical, (such as where Congressional authorization to purchase real estate for adequate safety clearances has not been granted or where significant impairment of the overall defense posture of the United States would otherwise result) and only if positive programs for the eventual correction of the deficiency are being carried out. Exemptions will not be granted for a period in excess of that estimated to be required for correction of the deficiency.

Explosion

A chemical reaction of any chemical compound or mechanical mixture which, when initiated, undergoes a very rapid combustion or decomposition releasing large volumes of highly heated gases which exert pressure on the surrounding medium. Also, a mechanical reaction in which failure of the container causes the sudden release of pressure from within a pressure vessel; for example, pressure rupture of a steam boiler. Depending on the rate of energy release, an explosion can be catagorized as a deflagration, a detonation, or a pressure rupture.

Explosives Facility

Any structure or location containing ammunition and explosives excluding combat aircraft parking areas or ammunition and explosives aircraft cargo areas.

Exposed Site (ES)

A location exposed to the potential hazardous effects (blast, fragments, debris, and heat flux) from an explosion at a potential explosion site (PES). The distance to a PES and the level of protection required for an ES determine the quantity of ammunition/explosives permitted in a PES.

Firebrand

A projected burning or hot fragment whose thermal energy is transferred to a receptor.

Fragmentation

The breaking up of the confining material of a chemical compound or mechanical mixture when an explosion takes place. Fragments may be complete items, sub-assemblies, pieces thereof, or pieces of equipment or buildings containing the items.

Hazardous Fragment

A hazardous fragment is one having an impact energy of 58 ft-lb or greater.

Hazardous Fragment Density

A density of nazardous fragments exceeding one per 600 sq. ft.

High Explosive Equivalent or Explosive Equivalent

The amount of a standard explosive which, when detonated, will produce a blast effect comparable to that which results at the same distance from the detonation or explosion of a given amount of the material for which performance is being evaluated. It is usually expressed as a percentage of the total net weight of all reactive materials contained in the item or system. For the purpose of these standards, TNT is used for comparison.

Holding Yard

A location for groups of railcars, trucks, or trailers used to hold ammunition, explosives, and dangerous materials for interim periods prior to storage or shipment.

Hygroscopic

A tendency of material to absorb moisture from its surroundings.

Hypergolic

A property of various combinations of chemicals to self-ignite upon contact with each other without a spark or other external initiation.

Inhabited Building(s)

Buildings or structures, other than operating buildings occupied in whole or in part by human beings, both within and outside DoD establishments. They include but are not limited to schools, churches, residences (quarters), service clubs, aircraft passenger terminals, stores, shops, factories, hospitals, theaters, mess halls, post offices, post exchanges, etc.

Inspection Station

A designated location at which trucks and railcars containing ammunition and explosives are inspected.

Interchange Yard

An area set aside for the exchange of railroad cars or vehicles between the common carrier and DoD activities.

Intraline Distance

The distance to be maintained between any two operating buildings and sites within an operating line, at least one of which contains or is designed to contain explosives, except that the distance from a service magazine for the line to the nearest operating building shall be not less than the intraline distance required for the quantity of explosives contained in the service magazine.

Launch Pads

The load-bearing base, apron, or platform upon which a rocket, missile, or space vehicle and its launcher rest during launching.

Liquid Propellant(s)

Liquid and gaseous substances (fuels, oxidizers, or mono-propellants) used for propulsion or operation of missiles, rockets, and other related devices (reference paragraph 8-9).

Loading Docks

Facilities, structures, or paved areas, designed and installed for transferring ammunition and explosives between any two modes of transportation.

Magazine

Any building or structure, except an operating building, used for the storage of ammunition and explosives.

Magazine, Earth-Covered, Non-Standard

All earth-covered magazines except those listed in paragraph 3-4A, B, and C with earth covering equal to or greater than that required by standard igloo magazines.

Mass-Detonating Explosives

High explosives, black powder, certain propellants, certain pyrotechnics, and other similar explosives, alone or in combination, or loaded into various types of ammunition or containers, most of the entire quantity of which can be expected to explode virtually instantaneously when a small portion is subjected to fire, to severe concussion or impact, to the impulse of an initiating agent, or to the effect of a considerable discharge of energy from without. Such an explosion normally will cause severe structural damage to adjacent objects. Explosion propagation may occur immediately to other items of ammunition and explosives stored sufficiently close to and not adequately protected from the initially exploding pile with a time interval short enough so that two or more quantities must be considered as one for quantity-distance purposes.

Maximum Credible Event (MCE)

A. General. In hazards evaluation, the maximum credible event from a hypothesized accidental explosion, fire, or agent release is the worst single event that is likely to occur from a given quantity and disposition of ammunition and explosives. Event must be realistic with a reasonable probability of occurrence considering the explosion propagation, burning rate characteristics, and physical protection given to the items involved. The MCE evaluated on this basis may then be used as a basis for effects calculations and casualty predictions.

B. Chemical Agent. A maximum credible event (MCE) for a chemical agent is defined as the hypothesized maximum quantity of agent that could be released from an ammunition item (without explosives), bulk container, or process as a result of a single unintended, unplanned or accidental occurrence. It must be realistic with a reasonable probability of occurrence.

Navigable Streams

Those parts of streams, channels, or canals capable of being used in their ordinary or maintained condition as highways of commerce over which trade and travel are or may be conducted in the customary modes, not including streams which are not capable of navigation by barges, tugboats, and other large vessels unless they are extensively and regularly used for the operation of pleasure boats.

NEQ
Net explosive quantity expressed in kilograms.

NEW

Net explosive weight expressed in pounds.

Nitrogen Padding (or Blanket)

To fill the void or ullage of a closed container with nitrogen gas to prevent oxidation of the chemical contained therein and to avoid formation of a flammable mixture, or to maintain a nitrogen atomsphere in or around an operation, piece of equipment, etc.

Non-DoD Components

Any entity (Government, private, or corporate) which is not a part of the Department of Defense.

Operating Building

Any structure, except a magazine, in which operations pertaining to manufacturing, processing, handling, loading, or assembling of ammunition and explosives are performed.

Operating Line

A group of buildings, facilities, or related work stations so arranged as to permit performance of the consecutive steps in the manufacture of an explosive; or in the loading, assembly, modification, and maintenance of ammunition.

Operational Shield

A barrier constructed at a particular location or around a particular machine or operating station to protect personnel, material, or equipment from the effects of a possible localized fire or explosion.

Passenger Railroad

Any steam, diesel, electric, or other railroad which carries passengers for hire.

Permissible Exposure Limits (PEL)

The maximum time weighted average airborne concentration (milligram/cubic meter) of a chemical agent to which it is believed that essentially all members of a specific population can be exposed for a specific period without adverse effect.

Pier

A landing place or platform built into the water, perpendicular or oblique to the shore, for the berthing of vessels.

Potential Explosion Site (PES)

The location of a quantity of explosives that will create a blast, fragment, thermal, and/or debris hazard in event of an accidental explosion of its contents. Quantity limits for ammunition/explosives at a PES are determined by the distance to an exposed site (ES).

Prohibited Area

A specifically designated area at airfields, seadromes, or heliports in which all ammunition and explosives facilities are prohibited.

Public Highway

Any street, road, or highway not under DoD custody used by the general public for any type of vehicular travel.

Public Traffic Route

Any public street, road, highway, navigable stream or passenger railroad (includes roads on a military reservation which are routinely used by the general public for through traffic).

Quantity-Distance (Q-D)

The quantity of explosives material and distance separation relationships which provide defined types of protection. These relationships are based on levels of risk considered acceptable for the stipulated exposures and are tabulated in the appropriate quantity-distance tables. Separation distances are not absolute safe distances but are relative protective or safe distances. Greater distances than those shown in the tables should be used wherever practicable.

Quay

A marginal wharf of solid fill.

Runway

Any surface on land designated for aircraft takeoff and landing operations - or a designated lane of water for takeoff and landing operations of seaplanes.

Service Magazine

A building of an operating line used for the intermediate storage of explosives materials.

Ship or Barge Units

All explosives within a line encompassing the ship or barge being loaded, the space on the pier for spotting of freight cars and trucks, and the space in the water for barges which may be working the ship or barge.

Single-Chamber Storage Site

An excavated chamber with its own access to the natural ground surface, not connected to any other storage chamber.

Source Emission Limits

The amount of chemical agent that may be released at a particular point which allows for natural dilution, ventilation, meteorological conditions interfacing, etc.

Standard Igloo Magazine

An earth-covered, arch-type magazine, with or without a separate door barricade, constructed according to an approved standard drawing identified in paragraph 3-4A, B, and C.

Static Test Stand

Locations whereon liquid propellant engines or solid propellant motors are tested in place.

Support Facilities

Ammunition and explosives storage or operations which solely support the function of tactical or using units as distinguished from storage depots or manufacturing facilities.

Suspect Truck and Car Site

A designated location for placing trucks and railcars containing ammunition or explosives that are suspected of being in hazardous condition. These sites also are used for trucks and railcars that may be in a condition that is hazardous to their contents.

Tactical Facilities

Tactical facilities are prepared locations with an assigned combat mission, such as missile launch facilities, alert aircraft parking areas, or fixed gun positions.

Taxiway/Taxilane

Any surface, designated as such in the basic airfield clearance criteria specified by a DoD Component publication or Federal Aviation Regulation (14 CFR 77).

Toxic Area

A defined area in which Storage Compatibility Group K ammunition or Class 6 chemical agents are handled or stored.

Waiver

Written authority which provides a temporary exception and permits deviation from a mandatory requirement of these standards. It is generally granted for short periods of time pending cancellation as a result of termination of scheduled work commitments or correction of the waived conditions.

Wharf

A landing place or platform built into the water or along the shore for the berthing of vessels.

Wharf Yard

A yard which is close to piers or wharves in which railcars or trucks are held for short periods of time prior to delivery to the piers or wharves.

CHAPTER 3

PRINCIPLES AND APPLICATION OF QUANTITY-DISTANCE, STANDARD EXPLOSIVES FACILITIES AND SITING REQUIREMENTS

3-1. Scope

This chapter sets forth:

A. Rules for the establishment of quantities of explosives.

B. Computations and determinations of quantity-distance.

C. Assessment of the explosion effects, such as facility damage and personnel injury expected at specific scaled distances for class 1 division 1 explosions.

D. Recommended methods of controlling the effects of class 1 division 1 explosions effects.

E. Acceptable exposures at specific scaled distances.

F. Types and general specifications of various ammunition and explosives facilities.

G. Siting requirements for specific facilities.

H. Requirements for site and construction plans review.

3-2. Establishment of Quantity of Explosives and Distances

A. Quantity of Explosives. The total quantity of explosives in a magazine, operating building, or other explosives facility shall be the net weight of the explosives calculated upon the following bases. Such calculations are intended for use with the tables in these standards.

1. Mass-Detonating Explosives. The net explosives weight (NEW).

2. Non Mass-Detonating Explosives.

a. Propellants. The net propellant weight.

b. Pyrotechnic Items. The sum of the net weights of the pyrotechnic composition and the explosives involved.

c. Bulk Metal Powders and Pyrotechnic Composition. The sum of the net weights of metal powders and pyrotechnic composition in containers.

d. Other Ammunition. The net weight of high explosives plus a suitable contribution, if any, from propellant, pyrotechnic components, or expelling charges. Reference chapter 4 for hazard classification testing requirements.

3. Combinations of mass-detonating and non mass-detonating ammunition and explosives (excluding class 1 division 4) shall be treated on the basis that all explosives are subject to mass-detonation and the total quantity used. A lesser quantity (i.e., total weight of H.E. plus the H.E. equivalent weight of other class 1 material present) may be used for quantity-distance purposes, subject to DDESB approval of supporting test data. In the event that the non mass-detonating items require a greater distance than the total explosives so computed, the greater distance is mandatory.

4. Combinations of non mass-detonating ammunition and explosives of different class 1 divisions shall be treated as follows:

Determine the required separation for each class/division, and use the greatest separation of those determined

B. Quantity-Distance Computations and Determinations

1. Throughout these standards, net explosive weight (NEW) is used to calculate distance by means of formulas of the type $D = KW^{1/3}$, where D is the distance in feet, K is a factor depending upon the risk assumed or permitted, and W is the net explosive weight in pounds. When metric units are used, the symbol Q denotes net explosive quantity in kilograms. In the formula $D = KQ^{1/3}$, the distance D is expressed in meters. Thus the respective units of K are $ft/lb^{1/3}$ and $m/kg^{1/3}$ in the two systems. The value of K in English units is approximately 2.5 times its value in metric units. For example, if $D(m) = 6Q^{1/3}$, then $D(ft) = 15W^{1/3}$. Distance requirements determined by the formula with English units are sometimes expressed by the value of K, using the terminology K9, K11, K18,... to mean K = 9, K = 11, K = 18, etc.

2. The quantity of explosives in a magazine, operating building, or other explosives site shall be considered the net weight of the controlling class of explosives contained therein (the class requiring the greatest separation).

a. Extensive tests and analytical work have proven that when two or more stacks of mass-detonating explosives detonate within short time intervals (the time in milliseconds is less than 3.2 times the cube root of the explosive weight in pounds for lateral target positions and less than 4.5 times the cube root of the explosive weight in pounds for axial target positions) the blast waves will coalesce. The combined shock wave, after coalescence, will be that of a single detonation of a charge equal to the summation of the several stacks. The actual separation time between successive detonations is influenced by the spatial separation of explosives, geometry and distribution, the character of the dividing wall or other barrier between, and the sensitivity of the explosives.

b. When it is considered advantageous for quantity-distance computations to subdivide a total quantity of mass-detonating explosives into smaller units, it must be insured by construction of a suitable barrier or provision of adequate separation that there will not be propagation from one to another. Design of intervening barriers in accordance with the principles contained in "Structures to Resist the Effects of Accidental Explosions" (TM 5-1300, AFM 88-22, NAVFAC P-397) will satisfy this requirement. If this requirement is met, the explosive content of the subdivision requiring the greatest distance will govern. If this requirement is not met, quantity-distance computations must be based upon the summation of the mass-detonating explosives in all of the subdivisions.

3. The quantity of explosives to be permitted in each of two or more locations shall be determined by considering each location as a potential explosion site. The quantity of explosives to be permitted in each of these locations shall be the amount permitted by the distance specified in the appropriate quantity-distance tables considering each as a potential target site in turn, except for service magazines. See paras 3-3A9 and 3-3B11.

4. Interpolation between distance increments specified in Class 1, Divisions 1 and 3 be made as follows:

a. Division 1. Interpolation shall be on the basis of the hazard factors specified in the Division 1 tables.

b. Division 3. Interpolation shall be linear and proportional.

5. Quantity-distance tables are to be found in Chapter 5.

6. It is impractical to specify quantity-distance separations allowing for the designed flight range of propulsive units (rockets, missile motors, catapults) which properly belong in class 1, divisions 1, 2, or 3. Therefore, maximum designed flight ranges for units in a propulsive state will be disregarded. The distance required to protect from fragments in credible accident situations, however, will be established in accordance with the principles in paragraph 5-2F.

7. Measurements of distance for determining the maximum allowable quantity of explosives shall be made from the nearest wall of the structure containing explosives, or nearest wall of the controlling subdivision when the structure is subdivided so that mass detonation between subdivisions will not occur, to the nearest part of an exposed structure or site. Separation distances are measured along straight lines.

8. Where railroad cars or motor vehicles containing ammunition and explosives are not separated from operating buildings, magazines, or open storage sites containing ammunition and explosives in such manner as to prevent their mass-detonation, the total quantity of explosives (paragraph 3-2A) in such locations, railcars, and motor vehicles shall be considered as a unit and the separation distance measured from the nearest outside wall of the building, railcar, vehicle, or edge of open stack, as appropriate, to a target. If the explosives are separated into smaller units so that mass-detonation of the explosives in the railcars and motor vehicles and inside unit or units will not occur, the separation distance shall be measured from the nearest controlling explosives unit, railcar, or vehicle to a target.

C. Class 1 Division 1 Explosion Effects Exposure Controls, and Degree of Safety Afforded

Facility damage and personnel injury assessment for class 1 division 1 are principally related to blast overpressure and impulse, although for limited amounts thereof, fragment hazards may be the controlling factor for quantity-distance determinations. For general purposes, peak incident overpressure is the blast parameter used herein to define maximum permissible levels of exposure. However, in specific instances the physical characteristics of exposed structures (e.g., mass, stiffness, ductility, etc.) make blast impulse the principal damage causing blast parameter.

1. The degree of safety afforded by the separation distances for standard igloo

magazines (Tables 5-3.4 and 5-3.5) may be described generally as providing virtually complete protection against propagation of explosions from one igloo magazine to adjacent igloo magazines by blast, fragments, and fire; however, there may be some cracking of concrete barrels and rear walls, possible severe cracking and some spalling of front walls, and some damage to doors and ventilators.

2. The degree of safety afforded by aboveground magazine distances of columns 8 and 9, Table 5-3.4 may be described, generally, as providing a high degree of protection against propagation of explosions from one aboveground magazine to adjacent aboveground magazines by blast; however, there may be considerable risk of delayed propagation by fragments or the spread of fire from one magazine to one or more of the other magazines depending upon ammunition type. Properly designed and placed barricades will reduce the risk of explosion communication by high-velocity low angle fragments. Without barricades, this risk is considered relatively high.

a. The aboveground magazine separation distance of $6W^{1/3}$ feet from W pounds ($2.4Q^{1/3}$ meters from Q kilograms) of explosives corresponds to a peak overpressure level of 27 psi or 1.8 bars (1 bar = 14.5 psi) when the explosion source is in the open. Neither the overpressure nor any other pertinent blast parameter such as impulse will be reduced significantly by the presence of an ordinary storage building of conventional unstrengthened industrial construction at the explosion site, or by the barricade required between aboveground magazines at this distance. A conventional unstrengthened building exposed at this distance will be completely destroyed, and any occupants will be killed by the direct action of blast, by being struck by building debris, or by impact against hard surfaces. Vehicles will be overturned and crushed by blast.

b. The unbarricaded aboveground magazine separation distance of $11W^{1/3}$ feet from W pounds ($4.4Q^{1/3}$ meters from Q kilograms) of explosives corresponds to a peak overpressure level of 8 psi (0.5 bars) from an explosion source in the open. Blast observed at this distance will be suppressed only negligibly by a storage building of conventional construction at the explosion site. An unstrengthened building exposed at this distance will suffer damage approaching total destruction, and any occupant will be killed or will incur serious injuries by blast to eardrums and lungs, and by being blown down or struck by fragments or building debris. Vehicles will be severely damaged by blast and will probably be inoperable.

3. The degree of safety afforded by the separation distance between the chambers in underground storage may be described, generally, as providing a high degree of protection against propagation of explosions from one chamber to an adjacent chamber by impact of spalled rock or material from chamber liner (Table 12-4.1).

4. Expected effects and controls at exposure level of 10-11 psi or .7 bar (1 bar = 14.5 psi) occurring at scaled distance of $9W^{1/3}$ feet from W pounds ($3.6Q^{1/3}$ meters from Q kilograms)... Refer Table 5-3.3 Column 3.

a. Unstrengthened buildings will suffer severe structural damage approaching total destruction.

b. Severe injuries or death to occupants of the exposed site are to be expected from direct blast, building collapse, or translation.

c. Aircraft will be damaged both by blast and fragments to the extent that they will be beyond economical repair. If the aircraft are loaded with explosives, delayed explosions are likely to result from subsequent fires.

d. Transport vehicles will be heavily damaged, probably to the extent of total loss.

e. Direct propagation of explosion between two explosives locations is unlikely when barricades are interposed between them to intercept high velocity low angle fragments.

f. Improperly designed barricades or structures may increase the hazard from flying debris, or may collapse in such a manner as to increase the risk to personnel and equipment.

g. Control. Barricading is required.(See paragraph 3-4.E). Exposed structures containing equipment of high monetary value or of critical mission importance or wherein personnel exposure is significant may require hardening for necessary protection of contents.

5. Expected effects and controls at exposure level of 3.5 psi (.24 bar) occurring at scaled distance of $18W^{1/3}$ ($7.2Q^{1/3}$)... Refer Table 5-3.3 Column 4.

a. Direct propagation of explosion is not expected.

b. Some possibility that delayed communication of an explosion may occur from fires, or as a result of equipment failure at the exposed site.

c. Damage to unstrengthened buildings will be of a serious nature and approximate 50 percent or more of the total replacement cost.

d. There is a 10 percent chance of eardrum damage to personnel.

e. Personnel injuries of a serious nature or possible death are likely from fragments, debris, firebrands or other objects.

f. Cargo ships would suffer damage to decks and superstructure from being struck by fragments and having doors and bulkheads on the weather deck buckled by overpressure.

g. Aircraft can be expected to suffer considerable structural damage from blast. Fragments and debris are likely to cause severe damage to aircraft at distances calculated from the formula $18W^{1/3}$ when small quantities of explosives are involved. (Refer Note 1, Table 6-3.2)

h. Transport vehicles will incur extensive, but not severe, body and glass damage consisting mainly of dishing of body panels and cracks in shatter-resistant window glass.

i. Control. Many situations arise in which control of pressure by suitably designed suppressive construction at the PES or protective construction at the exposed site are practical. Use of such construction to withstand blast overpressure is encouraged if it is more economical than distance alone, or if sufficient distance is not available to prevent the overpressure from exceeding this level.

6. Expected effects and controls at exposure level of 2.3 psi (.16 bar) occurring at scaled distance of $24W^{1/3}$ ($9.6Q^{1/3}$)... Refer Table 5-3.1

a. Unstrengthened buildings can be expected to sustain damage approximating 20 percent of the replacement cost.

b. Occupants of exposed structures may suffer temporary hearing loss or injury from secondary blast effects such as building debris and the tertiary effect of displacement.

c. Personnel in the open are not expected to be killed or seriously injured directly by blast. There could be some personnel injuries caused by fragments and debris depending largely upon the PES structure and amount of ammunition and fragmentation characteristics thereof.

d. Vehicles on the road should suffer little damage unless hit by a fragment or unless the blast wave causes momentary loss of control.

e. Aircraft should suffer some damage to appendages and sheet metal skin from blast and possible fragment penetration; however, the aircraft should be operational with minor repair.

f. Cargo type ships should suffer minor damage to deck structures and exposed electronic gear from blast and possible fragment penetration, but such damage should be readily repairable.

g. Control. The risk of injury or damage due to fragments for limited quantities of explosives at the PES can be reduced by barricading. Also, many situations arise where control of pressure by suitably designed suppressive construction at the PES or protective construction at the exposed site are practical.

7. Expected effects and controls at exposure level of 1.7 psi (.1 bar) occurring at scaled distance of $30W^{1/3}$ ($12Q^{1/3}$)...Refer Table 5-3.1.

a. Unstrengthened buildings can be expected to sustain damage approximating 10 percent of the replacement cost.

b. Occupants of exposed unstrengthened structures may suffer injury from secondary effects such as building debris.

c. Aircraft in landing and take-off status could lose control and crash.

d. Parked military and commercial aircraft will likely sustain minor damage due to blast but should remain airworthy.

e. Personnel in the open are not expected to be killed or seriously injured directly by blast. There could be some personnel injuries caused by fragments and debris depending largely upon the PES structure and amount of ammunition and fragmentation characteristics thereof.

f. Control. The risk of injury or damage due to fragments for limited quantities of explosives at the PES may be reduced by barricading or application of minimum fragment distance requirements.

8. Expected effects and controls at exposure level of 1.2 - 0.85 psi (.08 - .06 bar) occurring at scaled distance of $40W^{1/3}$ - $50W^{1/3}$ ($16Q^{1/3}$ - $20Q^{1/3}$) ... Refer Table 5-3.1.

a. Unstrengthened buildings can be expected to sustain damage up to about 5 percent of the replacement cost.

b. Personnel are provided a high degree of protection from death or serious injury, with injuries that do occur being principally caused by glass breakage and building debris.

c. Personnel in the open are not expected to be seriously injured directly by blast. There could be some personnel injuries caused by fragments and debris, depending largely upon the PES structure and amount of ammunition and the fragmentation characteristics thereof.

d. Control. Glass breakage and structural damage can be reduced by means of orientation and by keeping the surface area of exposed glass panels to a minimum.

3-3. Permissible exposures to blast overpressure

A. 10-11 psi or .7 bar occurring at $9W^{1/3}$ ($3.6Q^{1/3}$)...(Table 5-3.3 Column 3) (Barricade required (para 3-2C4g) unless otherwise indicated).

1. Buildings housing successive steps of a single production, renovation, or maintenance operation.

2. Security alert force buildings (see paragraph 5-2L).

3. Facilities of a tactical missile site where greater distances from the PES cannot be provided due to technical reasons.

4. Breakrooms and change houses if part of an operating line and used exclusively by personnel employed in operations of the line.

5. Temporary holding areas for trucks or railcars containing explosives to service production or maintenance facilities.

6. Field operations in magazine areas when performing minor maintenance, preservation, packaging or surveillance inspection (see para 5-4A2).

7. Unmanned auxiliary power facilities, transformer stations, water treatment and pollution abatement facilities, and other utility installations that serve the PES and are not an integral function in the PES, and loss of which would not create an immediate secondary hazard. These applications need not be barricaded. Exception: Unmanned auxiliary power generation or conversion facilities exclusively supplying power to the explosive storage area and security fence lighting may be located at fire distance from explosive facilities (80 feet for fire resistant structures, 100 feet for non-fire resistant structures).

8. Dunnage preparation and similar support structures housing non explosives operations if utilized only by personnel employed at the PES.

9. Service magazines which are part of operating lines. Distances are based on the quantity/type of ammunition or explosives in the service magazine(s), not the operating building.

10. Exposures as indicated in paragraph 3-3B if blast suppression, structure hardening, etc. provides comparable protection for personnel and equipment involved.

B. 3.5 psi (.24 bar) occurring at $18W^{1/3}$($7.2Q^{1/3}$...(Table 5-3.3 Column 4)

1. Workers engaged in construction in the vicinity of ammunition production areas, waterfront areas where ammunition is being handled or quantity-distance otherwise applies, or areas used for loading of aircraft with explosives.

2. Surveillance, maintenance and inspection buildings and labor intensive operations closely related to the PES.

3. Comfort, safety, and convenience occupied buildings exclusively in support of the PES (e.g., lunchrooms, motor pools, area offices, auxiliary fire stations, transportation dispatch points, and shipping and receiving buildings (not magazine area loading docks)).

4. Parallel operating lines from one another, whether or not barricaded, provided ammunition and explosives involved in each operating line present similar hazards. The criticality of survivability of one or more of the operating lines may require that each line be given an inhabited building level of protection.

5. Operations and training functions that are exclusively manned or attended by personnel of the unit operating the PES. This includes day rooms, squadron operation offices, and similar functions for units such as individual missile firing batteries, aircraft squadrons, or ammunition supply companies. Training functions permitted this level of exposure (3.5 psi, 0.24 bars) include organized classroom and field training of personnel who may be required to engage in explosives work at the PES. Maneuver areas, proving ground tracks, and similar facilities for armored vehicles also may be exposed to 3.5 psi

(0.24 bars) since the vehicle should provide adequate protection to the operators from fragments and debris.

6. Maintenance of military vehicles and equipment when the PES is basic load or ready storage located in OCONUS areas, and is limited to 4000 Kg or less NEW at each and when the maintenance work is performed exclusively by and for military personnel of the unit for which the basic load of ammunition is stored.

7. Auxiliary power and utilities functions excluding "cold iron" facilities, supply and mechanical support at naval station waterfront areas when not continuously manned, when serving only the waterfront area, and when the PES is a ship or ammunition handling location at the waterfront. This category includes: auxiliary power plants; compressor stations; electric power transformers; tool and consumable supplies storage and issue; and handling equipment service, battery charging, and minor repair. When such facilities serve an entire naval station or base complex, or when loss of the facility would cause an immediate loss of vital function, the exposure level must not exceed 1.2 psi (0.08 bars).

8. Minimum distance between separate groups of explosives loaded combat-configured aircraft or between aircraft and a pre-load or "quick turn" site which serves to arm the aircraft. The use of intervening barricades is required to further reduce communication and fragment damage and eliminate the necessity for totalling NEW. The loading of ammunition and explosives aboard aircraft can be accomplished within each group of aircraft without additional protection.

9. Parking lots for privately-owned automobiles belonging to the personnel employed at or stationed at the PES.

10. For separation of vessels involving ammunition and explosives, see chapter 7.

11. Service magazines which are part of operating lines. Distances are based on quantity/type of ammunition or explosives in the service magazine(s), not the operating building.

12. Container "stuffing" and "unstuffing" operations which are routine support of PES. This applies only to main support functions set aside for support of ship-loading or manufacturing operations. When the activity is in connection with ship-loading/unloading and the exposed site is an ammunition ship, the quantity at the container site will govern. (Container "stuffing/unstuffing" in a magazine area are permitted at intermagazine distances.)

13. Between explosives loaded combat aircraft and those non-explosives facilities which directly support the servicing and launching of a unit's armed aircraft (i.e., activities and their operating facilities that handle ammunition and explosives on the flightline, prepare and service armed aircraft, and those who fly combat aircraft. Direct flightline combat aircraft associated facilities may contain field offices, breakrooms, unit training rooms, and equipment and supply rooms, as well as POL hydrant facilities and CE fire protection stations). Specifically excluded are: morale, welfare and recreation (MWR) facilities; base civil engineering headquarters; industrial facilities, including central base supply; central maintenance control and associated critical shops, such as engine buildup or central avionic repair).

C. 2.3 psi (.16 bar) occurring at $24W^{1/3}$ $(9.6Q^{1/3})$...(Table 5-3.1).

1. Public traffic routes from "other PES" (Table 5-3.1) for NEW quantities less than 100,000 lbs (45,500 Kg).

2. Personnel exposed to remotely controlled operations (including control stations for operations provided with blast attenuating and fragment-defeating shields).

3. Open air recreation facilities exposed to "other PES" containing NEW of 100,000 lbs (45,500 Kg) or less where structures are not involved (e.g., ball diamonds, volley ball courts, etc.) used only by military personnel and provided for morale and health purposes at posts, camps, naval stations, air bases, and other operational military activities. When these recreation facilities are solely for off-duty recreation of personnel at their posts of duty, neither blast nor fragment quantity distances (Q-D) apply. This total relaxation of Q-D requirements applies only when the PES and the exposed site (ES) are closely related as with: an alert bomber and the recreation area for its crew; a navy tender and the recreation area for its crew and the crew of the tended ship; a security alert force and explosives facilities for which they are responsible and crews for quick reaction force armored vehicles and the explosives loaded vehicles that these crews are to man in event of military action. It is not intended that these relaxations be used to encourage the building of elaborate installations which substitute for properly located R&R facilities or that they encourage colocation of essentially unrelated military functions.

4. Training areas for unprotected military personnel exposed to "other PES" containing NEW of 100,000 lbs (45,500 Kg) or less. They include observation points and instruction areas for small arms and artillery firing ranges and similar fixed facilities designated for permanent use by groups or classes. The separation or other protection is required from permanent magazines and ammunition supply points but not from that ammunition and explosives needed for any particular exercise in order to achieve realism in training nor from explosives in necessary on-the-job training operations for explosives workers.

5. Private vehicle parking in administrative area when "other PES" contains NEW of 100,000 lbs (45,500 Kg) or less. Minimum fragment distance should be applied.

6. Aircraft passenger loading/unloading areas that do not include any structures.

D. 1.7 psi (.1 bar) occurring at $30W^{1/3}$ ($12Q^{1/3}$) ... (Table 5-3.1)

1. DoD use aircraft runways and taxiways exposed to ammunition and explosives storage and operating facilities (see tables 6-3.1, and 6-3.2).

2. Combat aircraft parking areas exposed to ammunition and explosives storage and operating facilities (see tables 6-3.1 and 6-3.2).

3. Public traffic routes.

4. Private vehicle parking in administrative areas. Minimum fragment distance should be applied.

5. Open air recreation facilities where structures are not involved (e.g., ball diamonds, volley ball courts, etc.) used only by military personnel and provided for morale and health purposes at posts, camps, naval stations, air bases, and other operational military activities. When recreation facilities are solely for off-duty military personnel at their posts of duty, neither blast nor fragment Q-D apply. This total relaxation of Q-D requirement applies only when the PES and the ES are closely related as with a security alert force and explosives facilities for which they are responsible. It is not intended that this relaxation be used to encourage the building of elaborate installations which substitute for properly located R&R facilities or that they encourage the colocation of essentially unrelated military functions.

6. Training areas for unprotected military personnel. They include observation points and instruction areas for small arms and artillery firing ranges and similar fixed facilities designated for permanent use by groups or classes. The separation or other protection is required from permanent magazines and ammunition supply points but not from that ammunition and explosives needed for any particular exercise in order to achieve realism in training nor from explosives in necessary on-the-job training operations for explosives workers.

7. Aircraft passenger loading/unloading areas that do not include a structure.

E. 1.2-0.85 psi (.08-.06 bar) occurring at $40W^{1/3}$ to $50W^{1/3}$ ($16Q^{1/3}$ to $20Q^{1/3}$),,,(Table 5-3.1 Column 3 between 100,000 lbs and 250,000 lbs)

1. Inhabited buildings, administrative and housing areas.
2. Installation boundaries.
3. Athletic fields and other recreation areas when structures are present.
4. Flight line passenger service functions.
5. Main power houses providing vital utilities to a major portion of an installation.
6. Storehouses and shops which by reason of their vital, strategic nature, or high intrinsic value of their contents, should not be placed at risk.
7. Functions which, if momentarily put out of action, would cause an immediate secondary hazard by reason of their failure to function.

3-4. Ammunition and Explosives Facilities

The following subparagraphs exemplify the types and general specifications and siting requirements of various magazines for ammunition, explosives and other dangerous materials.

A. Army Igloo Magazines

1. Reinforced concrete, arch-type, earth-covered magazines whose construction is at least equivalent in strength to the requirements of the Army, Office of Chief of Engineers drawings 652-686 through 652-693, dated 27 December 1941, as revised 14 March 1942, 33-15-58 (atomic blast resistant), 33-15-61, and 33-15-74 for all quantities of explosives up to 500,000 pounds.

2. Reinforced concrete, arch-type, earth-covered magazines whose construction is not equivalent in strength to the requirements of sub-paragraphs 3-4A1, for quantities of explosives up to 250,000 pounds.

B. Navy Arch-Type Magazines

1. Magazines constructed according to Navy drawings 357428 through 357430 dated 9 August 1944 and modified in accordance with NAVFAC drawing 626739 dated 19 March 1954, or new magazines constructed according to NAVFAC drawings 627954 through 627957, 764597, 793747, 658384 through 658388, 724368,751861 764596,and 793746 for all quantities of explosives up to 500,000 pounds.

2. Magazines constructed in accordance with NAVFAC drawings 649602 through 649605, 793748, and 803060 for all quantities of explosives up to 250 pounds.

C. Earth-Covered, Corrugated Steel, Arch-Type Magazine.

Structures at least equivalent in strength to those shown on Army, Office of Chief of Engineers drawings numbered AW 33-15-63 dated 5 Mar 1963, AW.

33-15-64 dated 10 May 1963, 33-15-65 dated 10 Jan 1963; NAVFAC Drawings Nos. 1059128-30, 1059132, 1069906, 1355460-61; or OCE Drawing No. OCE 33-15-73 (oval 1-ga steel arch) for all quantities of explosives up to 500,000 pounds.

D. Module, Open Storage, Barricaded.

1. A module (Figure 3-4.1) is a barricaded area composed of a series of connected cells with hard surface storage pads separated from each other by barricades. A light metal shed or other light-weight fire-retardant cover may be used for weather protection for individual cells. Heavy structures or flammable material will not be used.

2. Module storage (open storage) may be used as determined necessary by the DoD Component concerned. However, from the standpoint of explosives safety as well as reliability, priority should be given to covered storage (igloos) for items requiring protection from the elements. Module type storage is considered a temporary expedient and should not be employed in lieu of standard methods for long-term storage.

3. The maximum net weight of explosives permitted to be stored within each cell is 250,000 lbs.

4. Authorized Storage.

a. The items which may be stored in modules are limited to high explosive bombs, similarly cased class 1 division 1 ammunition, 20mm and 30mm ammunition in metal shipping containers, and CBU's in authorized non-flammable shipping containers.

b. Stocks in each module normally should be limited to one type of item in the standard shipping configuration unless mixed storage is authorized by the controlling authority.

c. Module storage of ammunition in flammable outer-pack configurations should be minimized.

d. Wher fire retardant tarpaulins are used for cover, sufficient ventilation between the tarpaulin and the stored ammunition shall be provided.

5. Barricade Requirements

a. All barricades used in forming the module and its cells shall meet the requirements specified in paragraph 3-4E. Minimum barricade height required above the top of the stack is influenced by the width or length of the stack (storage pad size) and the distance between the stack and the top of the barricade. Heights in Table 3-4.1 represent the minimum requirement for barricade locations based upon storage pad sizes and separations shown. Where feasible, barricade heights should be increased by using a 5^{o} angle above the horizontal instead of the 2^{o} shown in figure 3-4.1. Reference paragraph 3-4E2c.

b. The centerlines of barricades between cells of the module will be located at a point halfway between adjacent munitions storage pads. Back and end (outside) barricades will be located at the same distance from the pads as those between the cells.

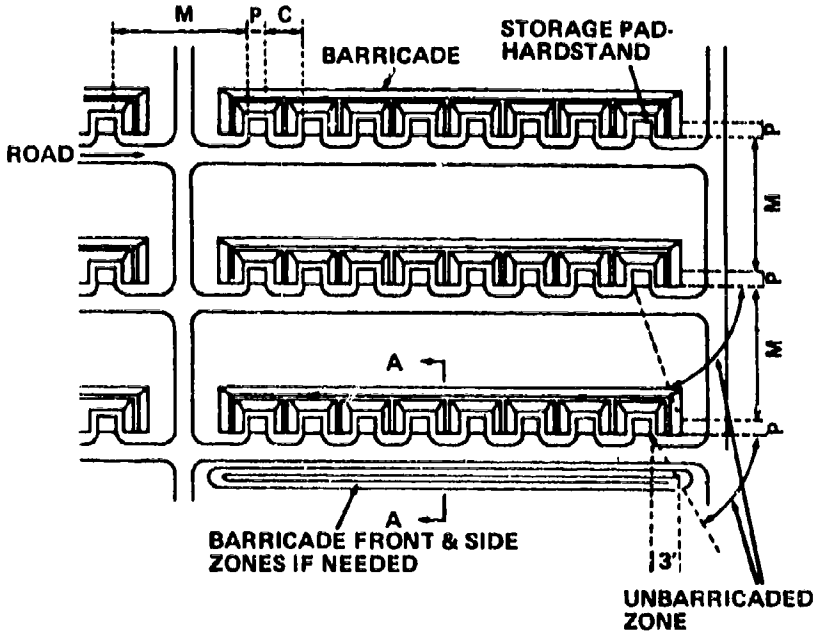
c. Maximum advantage should be taken of natural barriers existing in the topography in siting these modules. If natural barriers are used to substitute for a portion of the module barricade, the protection provided must be at least equivalent to that of the barricade.

6. Cell storage pad size may be as required to accommodate stocks. Table 3-4.1 gives minimum pad sizes necessary to handle most items in the explosives quantities given. Storage pads should be hard surfaced, if possible, in order to minimize the effects of earth shock from an accidental explosion. No restrictions are imposed upon the arrangement of cells within a module or upon the arrangement of groups of modules, except that cell openings will not face toward each other unless they are barri-

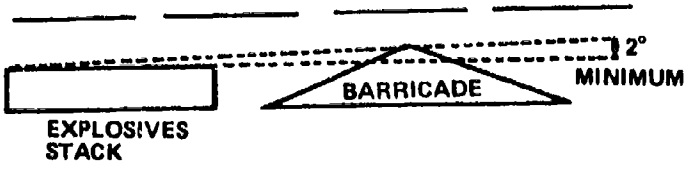
Table 3-4.1 - Intermagazine Separation for Barricaded Storage Modules for Mass-Detonating Explosives.

Net Pounds of Explosives	Minimum Explosives-to-Explosives Distance in Feet (Barricaded) Between	Barricade Height Based Upon Storage Pad Size	
	Cells & Modules $D = 1.1W^{1/3}$	Cell Storage Pad Size (width or depth) in Ft[1]	Min. Height of Barricade Above Top of Stack in Ft.
Column 1	Column 2	Column 3	Column 4
50,000	40	30	2
100,000	50	30	2
125,000	55	30	2
150,000	60	30	2
175,000	60	30	2
200,000	65	30	2
200,000	65	40	2½
225,000	65	40	2½
250,000	70	40	2½
250,000	70	50	3

[1] The barricade height above the explosives stack shown in Column 4 will be increased 6 inches for each 10 foot increase in width or depth of the pad size shown in column 3.



TYPICAL 8 CELL MODULE
NUMBER OF CELLS, CELL EXPLOSIVES WEIGHTS,
PAD SIZE (P), AND DISTANCES BETWEEN CELLS
(C) AND MODULES (M) VARY.



BARRICADE HEIGHT ABOVE EXPLOSIVES STACK

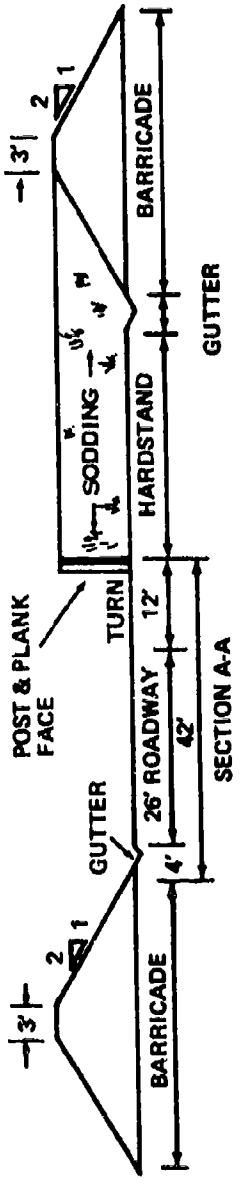


FIGURE 3-4.1 – TYPICAL 8 CELL MODULE

caded or meet the standard quantity-distance criteria for unbarricaded aboveground magazines.

7. *Siting Criteria.*

a. Separation between cells and modules.

(1) Distance between the nearest edges of the stacks of munitions in adjacent cells and modules will be as shown for appropriate explosives weights in Table 3-4.1. Where cell explosives loadings are established for weights other than those shown minimum distances between stacks will be determined by the formula: Distance = 1.1 times the cube root of the net weight of explosives in pounds ($D = 1.1W^{\frac{1}{3}}$).

(2) Deleted

b. Separation between modules and all other targets.

(1) Distance between a module and other magazines shall be determined by applying the intermagazine distances specified in Tables 5-3 and 5-5.

(2) Distances between the explosives in the cells of a module and all other targets will be determined upon the basis of the net explosives weight of single cells. Distances will be measured between the nearest edge of the munitions stack in the "controlling" cell and the nearest point of the target concerned. Reference paragraph 3-2B.

E. *Barricades and Earth Cover for Magazines.*

1. *General.* Properly constructed barricades or undisturbed natural earth are effective means for protecting ammunition and explosives, structures, or operations against high velocity low angle fragments although the barricades may be destroyed in the process. Since such fragments move along ballistic trajectories rather than straight lines, reasonable margins in barricade height and length must be provided beyond the minimum dimensions which block lines of sight. Barricades also provide limited protection against blast in the immediate vicinity. They do not provide any protection against high angle fragments and are ineffective in reducing the blast pressure in the far field (inhabited building or public traffic route distance).

2. *Barricade requirements.* Protection is considered effective when barricades meet the following minimum requirements:

a. The slope of a barricade shall not be steeper than 1½ horizontal to 1 vertical in order to meet explosives safety requirements. Facilities constructed in the future should have a slope of 2 horizontal to 1 vertical to reduce erosion and facilitate maintenance operations.

b. Earth barricades shall be made of material as indicated in paragraph 3-4E4, below.

c. The height and length of barricades shall be determined as follows:

(1) Height

Establish a reference point at the top of the far edge of one of the two stacks under consideration between which the barricade is to be constructed. This reference point, if the top of the stacks are not at the same elevation, shall be on the stack whose top is at the lower elevation. Draw a line from the reference point to the highest point of the other stack. Draw a second line from the reference point forming an angle of 2 degrees above the line. To preclude building excessively high barricades, the barricade should be located as close as possible to the stack on which the reference point was established. In the case where the stacks are of equal height, the reference point may be established on either stack. See Figure 3-4.2.

(2) Length

The length of the barricade will be determined as shown in Figure 3-4.3.

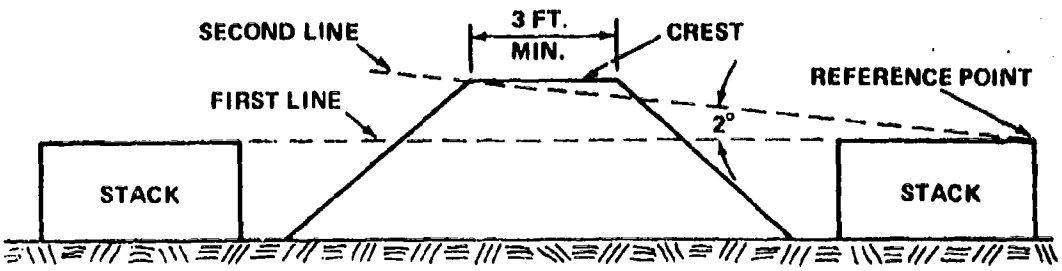
d. Earth barricades meeting the above requirements may be modified by substituting a retaining wall, preferably of concrete, for the slope on one side. The remaining side shall be of such slope and thickness as necessary to assure that the width of earth required for the top is held firmly in place.

e. Other intervening barriers meeting the requirements of a barricade as explained in chapter 2 or as proven by test may also be used; e.g., earth-filled steel bin barricades for explosives loaded aircraft.

3. *Location of Barricades.*

a. The distance between the foot of the barricade and the stack of ammunition or explosives or buildings containing explosives is necessarily a compromise. The smaller the distance, the less the height and length of the barricade required to secure proper geometry for intercepting projections. On the other hand, it may be essential to make the distance great enough to provide access for maintenance and vehicles.

b. If it is impracticable to locate the barricades as stated in paragraph a above, barricades



LEVEL TERRAIN
FIGURE 3-4.3

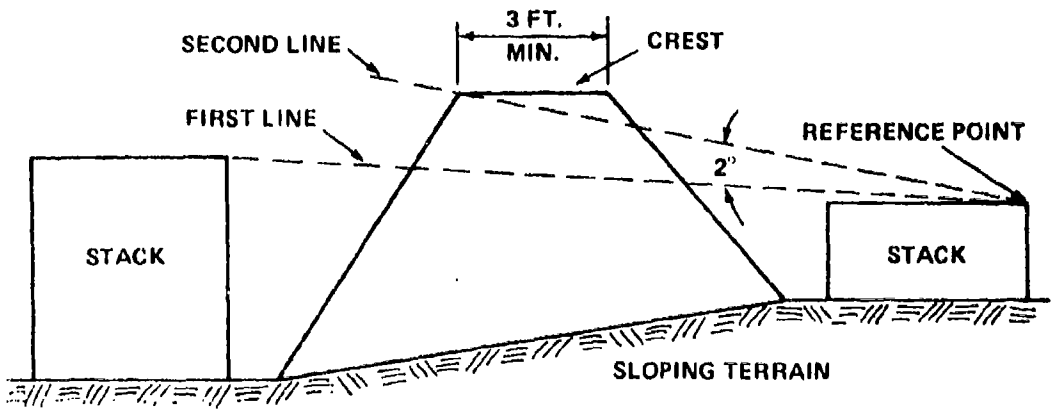


FIGURE 3—4. 2—DETERMINATION OF BARRICADE HEIGHT

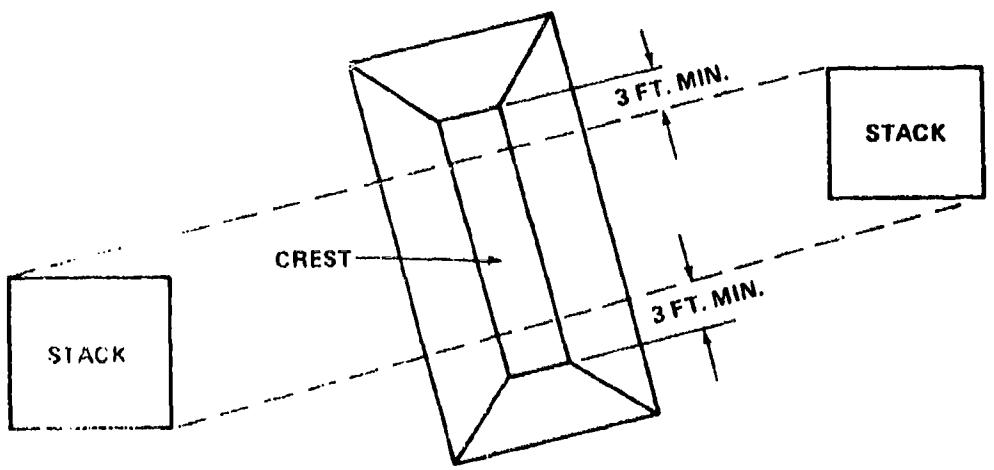


FIGURE 3—4. 3 —DETERMINATION OF BARRICADE LENGTH

may be located adjacent to the facility to be protected.

4. *Earth Cover for Magazines and Barricades.*

a. Material for earth cover over magazines and for barricades shall be reasonably cohesive (solid or wet clay and similar types of soil should not be used as they are too cohesive), free from deleterious organic matter, trash, debris, and stones heavier than 10 pounds or larger than 6 inches in diameter. The larger stones should be limited to the lower center of fills and not used for earth cover over magazines. Compaction and surface preparation shall be provided as necessary to maintain structural integrity and avoid erosion. Where it is impossible to use a cohesive material, for example in sandy soil, the barricade or the earth cover over magazines should be finished with a suitable material to insure structural integrity.

b. The earthfill or earth cover between igloo magazines may be either solid or sloped in accordance with the requirements of other construction features, but a minimum of 2 feet of earth cover must be maintained over the top of each magazine and a minimum slope of 1½ horizontal to 1 vertical starting directly above the spring line of each arch must be maintained to meet explosives safety requirements. Facilities constructed in the future should have a slope of 2 horizontal to 1 vertical to reduce erosion and facilitate maintenance operations.

F. Other Explosives Buildings and Magazines.

Existing facilities described by definitive drawings and specifically approved for the purpose by DoD Components are acceptable for handling and storage of ammunition and explosives. If existing facilities not so standardized are proposed for use in handling and storing ammunition and explosives, preliminary drawings will be submitted to DDESB for approval.

G. *Application of Quantity-Distance to Igloo Magazines.*

1. For application of quantity-distances, magazines must not have been structurally weakened to the extent that they could not be expected to prevent propagation of explosions. The specified thickness and slope of the earth cover must be maintained.

2. Determination as to whether construction of magazines is equivalent to the requirements of the applicable drawings shall be made by the DoD Component concerned.

3. Standard igloo magazines constructed in the future shall meet the minimum requirements of the current revisions of the drawings listed in subparagraphs A, B, and C above.

4. Normally, igloo magazines shall not be constructed to face door-to-door. They should face in the same direction with the long axes parallel to each other. In special cases where topographic or other important considerations would result in different orientations, they shall be sited in accordance with paragraph 5-4.

H. *Policy on Protective Construction*

The present "state of the art" in protective construction is such as to permit achievement of any calculated level of protection from explosion communication between adjacent bays or buildings; for personnel against death or serious injury from incidents in adjacent bays or buildings; and for vital and expensive equipment installations. Therefore, the major objectives in facility planning should be:

1. Provision of protection against explosion communication between adjacent bays or buildings and protection of personnel against death or serious injury from incidents in adjacent bays or buildings. Reference paragraph 3-2B and C. In situations where the protection of personnel and facilities would be greatly enhanced or costs significantly reduced by having separate buildings to limit explosion propagation rather than using protective construction and separation of explosive units within one building, planning should reflect this fact.

2. Provision of protection for vital and expensive equipment, if the additional cost is warranted.

3. When an appropriate degree of protection can be provided either by hardening a target building or construction of a source building to suppress explosion effects, these factors may be taken into account and the distances required by the standard quantity-distance tables may be reduced. Site and general construction plans for ammunition and explosives facilities which propose reduced distances based upon protective construction must be accompanied by the rationale or test results which justify the reduction when they are submitted for DDESB approval. Reference para 3-6.

3-5. Specific Siting Standards

The standards contained in this paragraph are specific requirements for the siting of facilities listed in following subparagraphs:

A. *Interchange Yards.* Truck, trailer, or railcar interchange yards are not subject to quantity-distance regulations, when they are used exclusively—

1. for the interchange of vehicles or railcars containing ammunition and explosives between the

commercial carrier and DoD activities (reference chapter 2):

2. to conduct external inspection of the trucks, trailers, railcars, or MILVANS containing ammunition and explosives; and

3. to conduct visual inspection of the external condition of the cargo in vehicles (trucks, trailers, railcars, MILVANS, etc.) that passed the external inspection. If the yards are used at any time for any purpose other than above, applicable quantity-distance tables apply. Reference paragraph 3-2B8.

B. Rail and Truck Holding Yards.

1. Generally, rail holding yards should be laid out on a unit car-group basis with each unit car-group separated by the applicable aboveground magazine distance.

2. If the rail holding yard is formed by two parallel ladder tracks connected by diagonal spurs, the parallel tracks and the diagonal spurs shall be separated by applicable abovegrcund magazine distances for the unit-group quantities of high explosives.

3. If the rail holding yard is a "Christmas Tree" arrangement, consisting of a ladder track with diagonal dead-end spurs projecting from each side at alternate intervals, the spurs should be separated by the applicable aboveground magazine distance for the net quantity of high explosives in the cars on the spurs.

4. Generally, truck holding yards should be laid out on a unit truck-group basis with each group separated by the applicable aboveground magazine distances.

5. Both rail and truck holding yards shall be separated from other facilities by the applicable quantity-distance criteria.

6. In addition to the temporary parking of railcars, trucks, trailers, or MILVANS containing ammunition and explosives, holding yards may also be used to interchange truck trailers or railcars between the commercial carrier and the DoD activity and to conduct visual inspections. Reference paragraph 3-5D.

C. *Classification Yard.*

1. For protection of the classification yard from external explosions, separation distances shall at least be the applicable magazine distance.

2. Specific quantity-distance separation is not required from the classification yard to targets other than explosive locations when the classification yard is used exclusively for:

a. receiving, dispatching, classifying and switching of cars (Reference chapter 2);

b. interchanging of trucks, trailers, railcars, or MILVANS between the common carrier and the DoD activity;

c. conducting external inspection of motor vehicles and railcars; or

d. opening of free rolling doors of railcars for the purposes of removing documents and making a visual inspection of the cargo. If the yard is used at any time for any other purpose, such as placing or removal of dunnage or explosive items into or from cars, quantity-distance tables apply. Reference paragraph 3-2B.

D. *Railcar and Truck Inspection Stations.*

1. Specific quantity-distance separations are not required for inspection stations; however, they should be as remote as practicable from hazardous or populated areas. Activities which may be performed at the inspection station after railcars or motor vehicles containing ammunition and explosives are received from the delivering carrier and prior to further routing within the installation are:

a. External visual inspection of the railcars or motor vehicles.

b. Visual inspection of the external condition of the cargo packaging in vehicles (trucks, trailers, railcars, MILVANS, etc.) which have passed the external inspection indicated above.

c. Interchange of trucks, trailers, railcars, or MILVANS between the common carrier and the DoD activity.

2. If any activities other than the above are conducted at the inspection station, quantity-distance applies.

3. Any cars or trucks suspected of being in a hazardous condition will be isolated consistent with applicable quantity-distance separation for the hazard class and explosives quantity involved. This shall be accomplished prior to any subsequent action.

E. *Administration and Industrial Areas.*

1. Administration and industrial areas shall be separated from explosives concentrations by inhabited building distances.

2. Auxiliary facilities such as joiner shops, heating plants, and field offices which are required to be at explosives operations and serving only one building or operation shall be so located and constructed as to provide prudent fire protection.

F. Inert Storage Area

It is the responsibility of the DoD Component concerned to determine the acceptable protection for such areas after consideration of the value and importance of material in relation to the mission of the installation, the operational conditions, and the availability of space.

G. Steel Tanks Built on or above the Surface of the Ground

Table 7-7.1, Column 4 distances shall be utilized for the separation distance between explosives concentrations and steel storage tanks which are built on or above the surface of the ground. The tanks indicated above are of the type commonly used for storage of petroleum products (POL), main water supply, and other liquids.

H. Underground tanks or pipelines

These should be separated from buildings or stacks containing ammunition and explosives of Hazard Classes 1, Divisions 2 through 4 by a minimum distance of 80 feet. The separation for Hazard Class 1, Division 1 should correspond to the formula $D = 3.0W^{1/3}$ with a minimum distance of 80 feet, unless the donor building is designed to contain the effects of an explosion.

I. Recreational, Training, and Other Such Areas

Open areas between explosive storage and handling sites and between these sites and non-explosive buildings and structures, should be carefully controlled regarding use for recreation or training facilities. As a general rule, the fragment hazard will be severe from the explosion site out to approximately the public traffic route distances. Accordingly, recreation and training facilities, where people are in the open, shall be sited at not less than public traffic route distances and preferably as near inhabited building distances as practicable. When structures, including bleachers, are included as part of these facilities, they shall be sited at not less than inhabited building distances.

J. Wharf Yard

Separation of a wharf yard from the pier which it serves by a distance clearly sufficient to prevent immediate propagation of an explosion (Table 5-3.4, Column 9) will be impracticable in many cases. In such cases, the wharf yard will be considered as a part of the ship or barge unit and added to it for computation of the total amount of explosives for quantity-distance purposes. The outer limit of the wharf yard will then be considered as the ship unit boundary for computing applicable quantity-distance requirements.

K. Demolition or Burning Areas

Sites for demolition and burning of explosives shall be separated from other facilities based on the hazards associated with the quantity and type of material to be destroyed. This is the responsibility of the using DoD Component.

L. Electric Power Lines. The following separation requirements apply to all new construction:

1. Electrical lines serving explosives operating facilities should be installed underground from a point not less than 50 feet away from such facilities.

2. Electrical service lines required to be in close proximity to an explosives operating facility should be no closer to that facility than the length of the lines between the poles/towers which support the lines unless effective means is provided to assure that energized lines cannot on breaking come into contact with the facility or its appurtenances.

3. Electrical distribution lines (those carrying less than 69 Kv), the towers/poles supporting these lines and unmanned electrical substations will be no closer to explosives exposures than public traffic route distances.

4. Electrical transmission lines (those carrying 69 Kv or more) and the towers/poles supporting them will be located no closer to PESs than (a) inhabited building distance if the line in question is part of a grid system serving a large off-base area; (b) public traffic route distance if loss of the line will not create serious social or economic hardships.

(Note: Public traffic route and inhabited building distances will be based on airblast overpressure only; fragment distances will not be used.)

M. Application of Quantity-Distance Standards Between Interservice Support Facilities and for Interservice Tactical Facilities.

1. General

a. Appropriate safety distances as provided for herein shall be applied between facilities of one service to facilities of another service regardless of the location of the boundary between the two service installations.

b. Safety criteria based on toxicity, noise, thermal radiation, flight trajectory, fragmentation, incendiary or other hazards may be greater than explosives safety distance criteria, in which case the criteria based on the predominant hazard should be considered.

2. The following quantity-distance relationships shall apply to the separation of facilities of two services, neither of which is a tenant of the other:

a. Explosives storage facilities of one Service shall be separated from explosives storage facilities of another Service, as a minimum, by appropriate intermagazine distance.

b. Explosives storage or operating locations of one Service shall be separated from explosives operating locations of another Service by appropriate inhabited building distance. When operations in each facility present a similar degree of hazard or for joint or support operations, this separation may be reduced to the appropriate intraline distance.

c. Explosives storage and operating locations of one Service shall be separated from explosives tactical facilities of another Service by appropriate inhabited building distance. For joint or support operations, use the appropriate separation distance as though both facilities belonged to a single Service.

3-6. Site and General Construction Plans Review

A. In accordance with para D.8, DoD Directive 5154.4, site and general construction plans for ammunition and explosives facilities as well as plans for changes in utilization of facilities or mission changes which adversely affect the explosives quantity-distance requirements shall be submitted to the Chairman, Department of Defense Explosives Safety Board (DDESB) for review and approval. Plans will be forwarded for:

1. New construction or major modifications of facilities for ammunition and explosives activities. Modifications or rehabilitation plans for existing facilities do not require submission to DDESB when the plans are minor in nature, do not introduce additional hazards, or do not increase the net explosives capacity or chemical agent hazard for which the facility was designed or sited.

2. Facilities for activities not involving ammunition and explosives which are in such proximity to ammunition and explosives as to be exposed to hazards if located at less than the prescribed quantity-distance criteria, and facilities for which a reasonable doubt might exist regarding possible exposure to hazards.

3. Facilities for activities not involving ammunition and explosives which become exposed to blast, fire, or fragment hazards; or potential toxic chemical agent release due to change in installation mission or facility usage. Example: An airfield restricted to DoD Component use only being changed to joint DoD/non-DoD use.

B. When the review of site and general construction plans is required, the DoD Component shall:

1. Specifically indicate in the letter of transmittal its approval of the proposal, along with changes, modifications, or specific precautionary measures considered necessary.

2. Submit drawings of site plans at a scale of 1 inch equals not more than 400 feet. The submission of drawings at a smaller scale than that specified may be necessary periodically to properly reflect certain distance and structure relationships within the area surrounding a given project. A reduction in scale in such instances is acceptable. When standard drawing(s) (definitive) for a building or group of buildings exist which have been reviewed by the DDESB and declared acceptable, the definitive drawing(s) is not required. In these cases only a site plan is required noting the definitive drawing(s) for each building or structure to be constructed.

3. Indicate distances between the facility to be constructed or modified and other installation facilities, the installation boundary, public railways and public highways, including power transmission and utility lines.

4. Identify all other facilities including their occupancy and use within inhabited building distance of the facility to be constructed or modified.

5. Provide descriptions of hazardous materials or items to be in the new or modified facilities; i.e., bombs, rockets, artillery ammunition, chemical agents, nuclear weapons, liquid propellants, or other items requiring protective measures in accordance with this standard. Include results of tests to determine blast, fragmentation, and thermal hazards.

6. Indicate quantities, class(es), and division(s) of ammunition, explosives, chemical agents, liquid and solid propellants, or other hazardous material proposed for the new or modified facility, including a breakdown by room or bay when appropriate.

7. Indicate NEW, class(es), and division(s) of ammunition, explosives, chemical agents, liquid and solid propellants, or other hazardous material in facilities located within inhabited building distance of the new or modified facility.

8. Provide anticipated personnel limits for the new or modified facility, including a breakdown by room or bay when appropriate.

9. Provide general details regarding dividing walls, vent walls, firewalls, roofs, operational shields, barricades, exits, types of floor finish, fire protection system installations, electrical systems and equipment, ventilation systems and equipment, hazardous waste disposal systems, lightning protection systems, static grounding systems, process equipment, and auxiliary support structures as well as general materials of construction unless approved definitive drawings are being used.

10. Furnish information on the type and arrangement of explosives operation or chemical processing equipment.

11. Provide a topography map with appropriate contours when terrain features are considered to constitute natural barricading, or topography otherwise influences layout as in some chemical operations.

12. Provide, in addition to the above and when chemical agents are involved, information regarding: personnel protective clothing and equipment; treatment of effluent and waste materials to assure absence of chemical agents; adequacy of medical support; average wind speed and direction; other support facilities pertinent to chemical safety; warning and detection systems; and hazard analysis, as appropriate.

13. Explain any deviations from pertinent safety standards due to local conditions.

C. The information in subparagraph B above will be submitted as follows:

1. Preliminary site plan approval - subparagraphs B1 through B7.

2. Final safety review - subparagraphs B1 through B12.

CHAPTER 4

EXPLOSIVES CLASSIFICATIONS AND COMPATIBILITY GROUPS

4-1. Scope

The purpose of this Chapter is to assure that DoD Components employ standard procedures for the determination of hazard characteristics of and assignment of hazard classifications to ammunition and explosives. Resultant assessments will provide the appropriate quantity-distance class, division, storage compatibility group, DOT class, and DOT marking for ammunition and explosives.

4-2. Explosives Hazard Classification Procedures

Department of Defense Explosives Hazard Classification Procedures (TB 700-2, NAVSEAINST 8020.3, TO 11A-1-47 and DLAR 8220.1) dated 1 March 1981, shall be used as a basis for assignment of hazard classes/divisions (para. 5-2E) to all explosives and ammunition except those which are candidates for designation as insensitive high explosives (para. 4-5A) and insensitive high explosives ammunition (para. 4-5B). Insensitive high explosives and insensitive high explosives ammunition shall be assigned to hazard classes/divisions as indicated in Tables 4-9.2 and 4-9.3, respectively, with prior DDESB approval.

4-3. DOT Class and DOT Marking

The procedures and information prescribed in the Code of Federal Regulations, Title 49-Transportation, shall be used in conjunction with determinations made in accordance with paragraph 4-2 above, for the additional assignment of appropriate DOT class and DOT marking.

4-4. Storage Compatibility Grouping

A. Compatibility Groups

All ammunition and explosives shall be assigned to an appropriate storage compatibility group (SCG) for storage at DoD activities.

B. Storage Principles

1. The highest degree of safety in ammunition and explosives storage could be assured if each item or division were stored separately. However, such ideal storage generally is not feasible. A proper balance of safety and other factors frequently requires mixing of several types of ammunition and explosives in storage.

2. Ammunition and explosives shall not be stored together with dissimilar materials or items which present positive hazards to the munitions. Examples are mixed storage of ammunition and explosives with flammable or combustible materials, acids, or corrosives.

3. Different types, by item and division, of ammunition and explosives may be mixed in storage provided they are compatible. Ammunition and explosives are assigned to an SCG when they can be stored together without significantly increasing either the probability of an accident or, for a given quantity, the magnitude of the effects of such an accident. Considerations which were used in developing the storage compatibility groups included but were not limited to:

a. Chemical and physical properties
b. Design characteristics
c. Inner and outer packaging configurations

d. Quantity-distance division
e. NEW
f. Rate of deterioration
g. Sensitivity to initiation
h. Effects of deflagration, explosion, or detonation.

4. Subject to application of these standards and particularly to compatibility as defined herein, ammunition and explosives should be mixed in storage when such mixing will facilitate safe operations and promote overall storage efficiency. Assignment of items to SCG's requiring separate storage should be minimized consistent with actual hazards presented and not based on administrative considerations or end use.

5. As used in these standards, the term "with its own means of initiation" indicates that the ammunition has its normal initiating device assembled to it and this device is considered to present a significant risk during storage. However, the term does not apply when the initiating device is packaged in a manner which eliminates the risk of causing detonation of the ammunition in the event of accidental functioning of the initiating device, or when fuzed end items are so configured and packaged as to prevent arming of the fuzed end items. The initiating device may even be assembled to the ammunition provided its safety features preclude initiation or detonation of the explosives filler of the end item in the event of an accidental functioning of the initiating device.

C. Compatible Ammunition and Explosives

1. Different kinds of explosives may be stored together. However, items in one of the three (3) groups listed below are not necessarily compatible with items in another of the groups--

a. the various kinds of initiating explosives are compatible one with another.

b. the various kinds of propellants are compatible one with another regardless of Q-D division and

c. the various kinds of high explosives are compatible one with another.

2. Different types of ammunition within any one of the following seven (7) groups are compatible and may be stored together--

a. all types of initiating devices;

b. all types of HE ammunition without their own means of initiation and without a propelling charge;

c. all types of HE ammunition without their own means of initiation and with a propelling charge;

d. all types of HE ammunition with their own means of initiation, with or without propelling charge;

e. all pyrotechnics and all types of ammunition containing both explosives and illuminating, incendiary, smoke or tear producing agents except:

(1) water activated pyrotechnics and ammunition;

(2) ammunition containing white phosphorus, flammable liquids or gels;

f. all types of ammunition containing both explosives and white phosphorus; and

g. all types of ammunition containing both explosives and flammable liquids or gels.

3. Ammunition items in one of the above groups are not generally compatible with items in other groups.

4. Certain kinds of explosives may be stored with certain types of ammunition:

a. Bulk propellants are compatible with propelling charges, and cartridges with inert or solid projectiles or without projectiles.

b. Bulk high explosives are compatible with HE ammunition without its own means of initiation and without a propelling charge.

5. Ammunition and explosives in substandard or damaged packaging, in a suspect condition, or with characteristics which increase the risk in storage are not compatible with other ammunition and explosives and shall be stored separately.

D. Storage Compatibility Groups

In view of ammunition and explosives storage principles and the considerations for mixed storage, ammunition and explosives are assigned to the appropriate one of twelve (12) Storage Compatibility Groups (A through H, J, K, L, and S).

1. Group A - Initiating explosives.

Bulk initiating explosives which have the necessary sensitivity to heat, friction, or percussion to make them suitable for use as initiating elements in an explosive train. Examples are wet lead azide, wet lead styphnate, wet mercury fulminate, and wet tetracene; dry RDX and dry PETN.

2. Group B - Detonators and similar initiating devices and not containing two or more independent safety features.

Items containing initiating explosives that are designed to initiate or continue the functioning of an explosive train. Examples are detonators, blasting caps, small arms primers, and fuzes.

3. Group C - Bulk propellants, propellant propelling charges, and devices containing propellant with or without their means of ignition.

Items that upon initiation will deflagrate, explode or detonate. Examples are single-, double-, triple-base, and composite propellants, rocket motors (solid propellant), and ammunition with inert projectiles.

4. Group D - Black powder, high explosives (HE), and ammunition containing HE without its own means of initiation[1] and without propelling charge, or a device containing an initiating explosive and containing two or more independent safety features.

Ammunition and explosives that can be expected to explode or detonate when any given item or component thereof is initiated except for devices containing initiating explosives with independent safety features. Examples are bulk TNT, Comp B, black powder, wet RDX or PETN, bombs, projectiles, CBU's, depth charges, and torpedo warheads.

[1] Reference paragraph 4-4B5.

5. Group E - Ammunition containing HE without its own means of initiation[1] and with propelling charge (other than one containing an inflammable or hypergolic liquid).

Ammunition or devices containing HE and containing propelling charges. Examples are artillery ammunition, rockets, or guided missiles.

6. Group F - Ammunition containing HE with its own means of initiation[1] and with propelling charge (other than one containing an inflammable or hypergolic liquid) or without a propelling charge.

HE ammunition or devices (fuzed) with or without propelling charges. Examples are items initiated by means of a bouchon firing device, grenades, sounding devices, and similar items having an in-line explosive train in the initiator.

7. Group G - Fireworks, illuminating, incendiary, smoke including HC, or tear producing munitions other than those munitions that are water activated or which contain white phosphorus, or flammable liquid or gel.

Ammunition that, upon functioning, results in an incendiary, illumination, lachrymatory, smoke, or sound effect. Examples are flares, signals, incendiary or illuminating ammunition, and other smoke or tear producing devices.

8. Group H - Ammunition containing both explosives and white phosphorus or other pyrophoric material.

Ammunition in this group contains fillers which are spontaneously flammable when exposed to the atmosphere. Examples are WP, PWP, or other ammunition containing pyrophoric material.

9. Group J - Ammunition containing both explosives and flammable liquids or gels.

Ammunition in this group contains flammable liquids or gels other than those which are spontaneously flammable when exposed to water or the atmosphere. Examples are liquid or gel filled incendiary ammunition, FAE devices, flammable liquid fueled missiles, and torpedoes.

10. Group K - Ammunition containing both explosives and toxic chemical agents.

Ammunition in this group contains chemicals specifically designed for incapacitating effects more severe than lachrymation. Examples are artillery or mortar ammunition, fuzed or unfuzed, grenades, rockets or bombs filled with a lethal or incapacitating chemical agent. Reference note 4, Figure 4-4.1.

11. Group L - Ammunition not included in other compatibility groups.

Ammunition having characteristics that do not permit storage with other types of ammunition, or kinds of explosives, or dissimilar ammunition of this group. Examples are water activated devices, prepackaged hypergolic liquid-fueled rocket engines, certain fuel-air explosive devices (FAE), TPA (thickened TEA), and damaged or suspect ammunition of any group. Types presenting similar hazards may be stored together but not mixed with other groups.

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[1] Reference paragraph 4-4B5.

Figure 4-4.1 - Storage Compatibility Mixing Chart

GROUPS	A	B	C	D	E	F	G	H	J	K	L	S
A	X	Z										Z
B	Z	X										X
C			X	Z	Z		Z					X
D			Z	X	X							X
E			Z	X	X							X
F						X						X
G			Z				X					X
H								X				X
J									X			X
K										Z		
L												
S	Z	X	X	X	X	X	X	X	X			X

NOTE:

1. The marking "X" at an intersection of the above chart indicates that these groups may be combined in storage. Otherwise, mixing is either prohibited or restricted per note 2 below.
2. The marking "Z" at an intersection of the above chart indicates that when warranted by operational considerations or magazine non availability, and when safety is not sacrificed, logical mixed storage of limited quantities of some items of different groups may be approved. These relaxations involving mixed storage are to be approved by the controlling DoD Component and are not considered waivers. Combinations that violate the principles of paragraph 4-4B3 require justification by a waiver or exemption. Examples of acceptable combinations of class 1 are:
   a. Division 1 group C bulk propellants with division 1 bulk HE.
   b. Division 1 group C rocket motors with division 1 group D bombs(HE) without their own means of initiation.
   c. Group C rocket motors with group E complete rocket systems having the same rocket motor.
   d. Division 3 group C bulk propellants or bagged propelling charges with division 3 group G pyrotechnics without their own means of initiation.
3. Equal numbers of separately packaged components of complete rounds of any single type of ammunition may be stored together. When so stored, compatibility is that of the assembled round, i.e., WP filler in group H, HE filler in groups D, E, or F, as appropriate.
4. Group K requires not only separate storage from other groups, but may also require separate storage within the group. The controlling DoD Component shall determine which item under group K may be stored together and those which must be stored separately.
5. Ammunition items without explosives which contain substances properly belonging to another hazard class may be assigned to the same compatibility group as items containing explosives and the same substance, and be stored with them.
6. DoD Components may authorize ammunition designated "Practice" by FSN and nomenclature to be stored with the fully loaded ammunition it simulates.
7. DoD Components may authorize the mixing of compatibility groups, except items in groups A, B and L in limited quantities. Such mixed storage is not to exceed 1000 pounds net explosive weight and will be considered as the highest division included.

12. Group S - Ammunition presenting no significant hazard.

Ammunition so packaged or designed that any hazardous effects arising from accidental functioning are confined within the package unless the package has been degraded by fire, in which case all blast or projection effects are limited to the extent that they do not significantly hinder firefighting. Examples are thermal batteries, explosive switches or valve, and other ammunition items packaged to meet the criteria of this group.

E. Mixed Storage. Mixing of SCG's is permitted as indicated in Figure 4-4.1.

F. Riot Control Agent. Articles which contain riot control substances without explosives components are classified as class 6 division 1 in the United Nations Recommendations. For DoD purposes, these articles may be considered as 1.4G and may be stored in limited quantities with other base defense munitions. Bulk agent is class 6.1 in the UN Recommendations.

4-5. Insensitive High Explosives and Insensitive High Explosives Ammunition

A. Insensitive high explosives (IHE) comprise class/division 1.1 explosive substances which although mass detonating, are so insensitive that there is negligible probability of initiation or transition from burning to detonation in transport or in storage.

B. Insensitive high explosives ammunition is ammunition which contain IHE substances and which have demonstrated through test results (para 4-9) that the mass and confinement effects of the ammunition case are negligible on the probability of initiation or transition from burning to detonation of the IHE in transport or storage. Such ammunition when intentionally initiated will be incapable of transferring detonation to another (i.e., propagating)

4-6. Test Procedures Documents

The following documents set forth procedures to be used in the IHE and IHE ammunition testing required by paragraphs 4-7 through 4-9.

TB = DoD Hazard Classification Procedures (TB 700-2), 1 March 1981

JSSPM = Joint Services Safety & Performance Manual (1972)

WR 50 = Warhead Safety Tests, Minimum for Air, Surface & Underwater Launched Weapons

JMEM = Joint Munitions Effectiveness Manual, Air-To-Surface Joint Service Test Procedures for Bombs and Bomblets - NAVAIR 00-130-ASR-2-1(Dec 68)

4-7. Screening Tests for IHE

Substances which are candidates for designation as IHE shall be subjected to the screening tests specified below. Failure to achieve required results in a single test should not be regarded as disqualifying provided all others are achieved. However, it does signal the need for careful evaluation.

Test	Test Procedures Document	Required Results
Impact Test	TB 700-2	Sensitivity less than Explosive D
Friction Test	JSSPM	No reaction
Differential thermal analysis (DTA)	JSSPM	No exotherm at 250°C
Small scale burn	TB 700-2	No detonation or violent reaction
Spark Tests	JSSPM	No reaction at 0.25 joule

4-8. Qualification Tests for IHE

Substances judged on the basis of screening test results stated in paragraph 4-7 to be legitimate candidates for designation as IHE shall be subjected to tests specified in Table 4-8.1. Required results as stated must be achieved for qualification as IHE.

4-9. Qualification Tests for IHE ammunition

To qualify as IHE ammunition, ammunition containing insensitive high explosives must be subjected to tests specified in Table 4-9.1 and achieve required results as stated. In addition, it must be demonstrated by actual test, that intentional detonation of item will be incapable of propagating detonation to another like item.

4-10. Hazard Classifications and Compatibility Groups

Table 4-10.1 provides examples of the relationship between storage compatibility groups, quantity-distance divisions and DOT classes for items classified in accordance with TB 700-2. Tables 4-10.2 and 4-10.3 assign quantity-distance divisions and storage compatibility groups to substances qualified as IHE under the provisions of paragraph 4-8 and ammunition qualified as IHE ammunition under provisions of paragraph 4-9.

4-11. Class 1 or 6. Chemical Agent Hazards or Combined Chemical Agent and Explosives Hazards

Items in these classes are chemical agent filled ammunition, chemical agents, and chemical agent filled components. Depending upon the type of agent, its persistency, toxicity, or other characteristics, the primary safety consideration may be the area of agent dispersal rather than blast or fragment distance which usually control in the case of other ammunition. Items which contain only toxic chemical components are assigned to class 6, division 1. Items which contain both explosives and toxic chemical components are assigned to class 1, divisions 1 through 4, as appropriate. Class 6, division 1 requirements must also be applied so that the explosives and toxic chemical hazards are both considered.

Table 4-8.1 Qualification Tests for IHE

Test	Test Procedures Document	No. of Trials	Sample[1]	Required Results[2]
Critical diameter test	JSSPM		$L_s/D_s = 4$ D(inches) increased in 1 inch increments (1,2,3, etc.)	Critical diameter = Minimum diameter sample for steady state detonation
Cap test	TB	5	$L_s/D_s = 4$ $D_s = 3xD_c$	No reaction
Card gap test	TB		D_s = (see note 3 below)	No reaction at (see note 4)
Slow cook-off test	WR-50	3	$L_s/D_s = 4$; $D_s = 3xD_c$ (confined in Sched 40 pipe, capped at 150 ft-lb torque)	No detonation or violent reaction with fragment throw
External fire test	TB	3	$L_s/D_s = 4$; $D_s = 3xD_c$ (confined in Sched 40 pipe, capped at 150 ft-lb torque)	No detonation or violent reaction with fragment throw
Susan test	JSSPM	3		Less than 10% TNT equivalent output
Bullet impact test	JSSPM	6	$L_s/D_s = 4$; $D_s = 3xD_c$ (confined in Sched 40 pipe, capped at 150 ft-lb torque) 3 trials in axial orientation and 3 trials in longitudinal orientation	No reaction when impacted by 0.50 caliber projectile

1 L_s = Sample length; D_s = Sample diameter

2 D_c = Critical diameter

3 The test sample shall have a length to diameter ratio of 3.83 where the sample diameter is either 1.44 inches or 2.94 inches depending, respectively, upon whether the test material has a confined $d_c \leq .72$ in. or $0.72 \text{ in.} < d_c \leq 1.47$ in.

4 Where a substance has an unconfined or confined $d_c \geq .72$ in., it shall be tested at a gap of .69 inches. Should the substance detonate during any trial, it may not be classed as an IHE. Where a substance has a confined critical diameter $0.72 \text{ in.} < (d_c) \leq 1.44$ in., it shall be tested at a gap that correlates to the .69 in. gap for the smaller diameter test. Should the substance detonate during any trial, it may not be classed as an IHE.

Table 4-9.1 Qualification Tests for IHE Ammunition

Test	Test Procedures Document	Sample	Stimulus	Required Result
Sled test	JMEM	All-up round/ w.o. overpack	Impact hard surface at 450 meters per second velocity	No detonation
Bonfire	TB	Ammo in storage & shipping configuration	Open fire	No detonation
Propagation	WR-50	Ammo in storage & shipping configuration	Detonated all-up round in storage/shipping configuration	No propagation of detonation
Slow cook-off	WR-50	Ammo in storage & shipping configuration	Heat to reaction temperature	No detonation or violent reaction with fragment throw
Multiple bullet impact	WR-50	All-up round in 3 different orientations	.50 cal AP ammo fired at service velocity in 3-round bursts	No detonation

Table 4-10.1 - Hazard Classifications/Compatibility Groups

	Items	SCG	Q-D Class 1 Division	DOT Class
1.	Initiating explosives	A	1	A
2.	Detonators and similar initiating devices	B	1,2, or 4	A or C
3.	Bulk propellants, propelling charges, and devices containing propellant with or without means of ignition	C	1,2,3, or 4	A,B, or C
4.	Black powder, high explosives, and HE ammunition without its own means of initiation and without a propelling charge	D	1 or 2	A
5.	HE ammunition without its own means of initiation, with a propelling charge	E	1 or 2	A
6.	HE ammunition with its own means of initiation, with or without a propelling charge	F	1 or 2	A
7.	Fireworks and illuminating, incendiary, smoke, or tear producing ammunition other than ammunition that is activated by exposure to water or the atmosphere	G	1,2,3, or 4	A,B, or C
8.	Ammunition containing both explosives and white phosphorus or other pyrophoric material	H	2 or 3	A or B
9.	Ammunition containing both explosives and flammable liquid or gel filler	J	3	B
10.	Ammunition containing both explosives and toxic chemical agent	K	2	A
11.	Ammunition, not included in other groups, requiring separate storage	L	1,2,3, or 4	A,B, or C
12.	Ammunition which presents no significant hazards	S	4 or None	C or exempt

Table 4-10.2 IHE Hazard Classifications/Compatibility Groups

IHE stored alone	1.3c
IHE stored at magazine distance or greater from class 1.1	1.3c
IHE stored at magazine distance or greater from class 1.2	1.3c
IHE stored with 1.1c items	1.1c
IHE stored with 1.2c items	1.1c
IHE stored with other 1.3c items	1.3c
IHE stored with 1.4c items	1.3c
IHE stored at less than magazine distance from class 1.1	1.1c
IHE stored at less than magazine distance from class 1.2	1.1c

Table 4-10.3 IHE Ammunition Hazard Classification/Compatibility Groups

Warheads that are certified as invulnerable to accidental detonation by arming and firing system	1.4d
Warheads that are not certified as invulnerable to accidental detonation by arming and firing system	1.2d
All-up rockets with 1.3 motors and warheads that are certified as invulnerable to accidental detonation by arming and firing system	1.3c
All-up rockets with 1.3 motors and warheads that are not certified as invulnerable to accidental detonation by arming and firing system	1.2e

NOTE:

When stored with compatible items of other Q-D classes, the most restrictive Q-D class will apply to the combination.

CHAPTER 5

HAZARD CLASSIFICATION AND QUANTITY-DISTANCE CRITERIA

5-1. Scope

This chapter establishes the DoD hazard classification system and quantity-distance criteria to be applied in the development, manufacture, test, maintenance, storage, loading into and unloading from vehicles, and disposal of ammunition and explosives and all handling incident thereto. These class and division designations for ammunition and explosives provide specific levels of protection for personnel and property within and outside of military installations from the effects of possible fires or explosions.

5-2. Hazard Classes & Class Divisions

A. The new hazard classification system is based upon the system recommended for international use by the United Nations Organization (UNO) which consists of nine (9) classes for dangerous goods with ammunition and explosives included in UNO "Class 1, Explosives." Ammunition without explosive components which contains toxic chemical agents, and containers of toxic chemical agents in bulk are included in UNO "Class 6, Poisonous (Toxic) and Infectious Substances."

B. The new ammunition and explosives hazard classes are further subdivided into "divisions" based on the character and predominance of the associated hazards and of the potential for causing personnel casualties or property damage; not upon compatibility groupings or intended use. The list of items for each division contains examples of the type of product in that division, but does not enumerate all articles which may be included in the division.

C. The separation of the ammunition and explosives hazard classes into the several divisions does not necessarily mean that the different items in a division may be stored together. Also, some items may appear in more than one division depending upon such factors or combinations thereof as the degree of confinement or separation, type of packaging, storage configuration, or state of assembly.

D. The maximum amount of explosives or chemical agent permitted in any location is limited by the quantity-distance criteria of these standards. Explosives and chemical agent limits shall be established in amounts no greater than those consistent with safe and efficient operations.

E. Class 1 is divided into four (4) divisions which indicate the types of hazards expected:

Hazard Class and Division Designators	*Hazards*
1.1	*Mass-detonating*
1.2	*Non Mass-detonating Fragment Producing*
1.3	*Mass-fire*
1.4	*Moderate fire, no blast*

F. A numerical figure (in parenthesis) is used to indicate the minimum separation distance (in hundreds of feet) for protection from debris, fragments, and firebrands. This number will be placed to the left of the division designators 1.1 thru 1.3, such as (18)1.1, (08)1.2, and (06)1.3. A minimum distance as shown in applicable tables will be used for all items in division 1.2.

1. For divisions 1.1 and 1.3, a minimum distance number will be used where the ranges of hazardous fragments and firebrands (see chapter 2) exceed the distances specified for inhabited buildings in the applicable quantity-distance table.

2. Minimum fragment distances are to protect personnel in the open; firebrand distance minima primarily are to protect facilities. They will be applied to:

a. Installation boundaries (para 5-2J)

b. Administration and housing areas.

c. Athletic and other recreation areas except those described in para 5-2F3a.

d. Flight line passenger service functions.

e. Main power houses providing vital utilities to a major portion of the installation.

f. Storehouses and shops which by reason of their vital, strategic nature, or the high intrinsic value of their contents, should not be placed at risk.

g. Functions which, if momentarily put out of action, would cause an immediate secondary hazard by reason of their failure to function.

3. Examples where minimum fragment and firebrand distances for divisions 1.1 and 1.3 need not be applied are:

a. Recreation or training facilities if these facilities are for the exclusive use of personnel assigned to the potential explosion site (para 3-5I).

b. Related and support DoD-controlled functions for which intermagazine and intraline distances are the usual protection levels (para 3-3B2).

c. Maintenance, supply, and training facilities, and operations offices for the service of the logistics and operations functions of combat aircraft, Army battalion-size or smaller delivery or ammunition supply units, separate air defense firing batteries, or a single pier/wharf for which the ammunition in the potential explosion site is intended.

d. Between potential explosion sites and relatively static inert storage areas, including parking areas for dead storage of military aircraft or vehicles.

e. Between facilities in an operating line; between operating lines; and between operating lines and storage locations which are normally separated by inhabited building distances to protect workers and insure against interruption of production.

4. For demolition explosives, thin-cased or low fragmentation ammunition items, bulk high explosives, pyrotechnics, and in-process explosives of division 1.1 the minimum distance to exposures listed in paragraph 5-2F2 above will be 670 feet for 100 lbs NEW or less. For all types of division 1.1 in quantities of 101 to 30,000 lbs NEW, the minimum distance will be 1250 feet unless it can be shown that fragments and debris from structural elements of the facility or process equipment will not present a hazard beyond the distance specified in table 5-3.1. For items that have been adequately evaluated, a different minimum distance(s) such as in table 5-3.2 may be used. In the application of this paragraph, "thin-cased" will be taken as presenting no more hazard from high velocity primary fragments than that from a single 500-lb MK 82 bomb. (Facilities sited at 1235 or 1243 feet in accordance with past standards will be considered to be in compliance with the 1250 foot minimum requirement).

5. For public traffic routes which are not possible sites for future targets, and for other exposures permitted at public traffic route distances (para 3-5I) from potential explosion sites, fragment and firebrand distance minima for divisions 1.1 and 1.3 may be reduced to 60 percent of these distance minima.

G. Figure 5-2.1 may be used to facilitate the transition from the former DoD quantity-distance classes to the new system.

H. When determining inhabited building and public traffic route distances, use table 5-3.1 for class 1 division 1; table 5-3.2 for certain specified class 1 division 1 items; tables 5-5.1 thru 5-5.4 for class 1 division 2; table 5-6.1 for class 1 division 3; and table 5-7.1 for class 1 division 4.

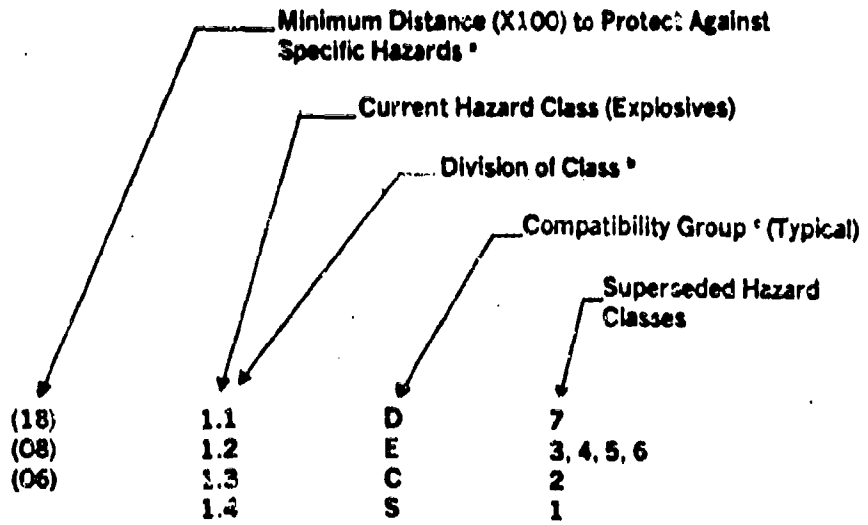
I. When determining intraline and intermagazine distances, use tables 5-3.3 thru 5-3.5 for class 1 division 1; tables 5-5.1 thru 5-5.4 for class 1 division 2; table 5-6.1 for class 1 division 3; and table 5-7.1 for class 1 division 4.

J. In the application of inhabited building and public traffic route distances, table 5-3.1, the installation boundary or limits of property under DoD control will be treated as the governing target unless manifestly inapplicable (unsuitable terrain, government land not open to public). In interpreting application to navigable waterways as public traffic routes, the explanation of navigable streams as given in chapter 2 will be literally observed. Occasional small fishing and pleasure craft may be ignored.

K. Deleted.

L. Inhabited building distances need not be applied to facilities for the housing of security personnel who are required by their mission to have a quick reaction capability in the immediate vicinity of a potential explosion site. Such security facilities may be sited at a minimum of $D = 9W^{1/3}$. Peak incident overpressures to be expected from an explosion at this distance will be about 11 psi and are sufficient to render the alert force personnel within the building militarily ineffective. Strengthening the building to withstand small arms fire is considered to provide reasonable protection against fragments and building debris, but not necessarily against blast. Consideration should therefore be given to strengthening this building (reference para 3-4H3) to provide blast protection to the occupants. This criteria applies to any manned security facilities regardless of continuous occupancy and numbers of duty personnel, but may not be extended to barracks which are the permanent quarters of assigned troops. Individual sentry posts are not subject to quantity-distance separation standards, but should be so located as to provide prudent fire protection for the explosive facility.

FIGURE 5-2.1—APPLICATION OF HAZARD CLASSIFICATION SYSTEM



NOTES:
- a—Varies with type of ammunition and item
- b—Class Divisions
  - 1.1—Mass-Detonating
  - 1.2—Non Mass-Detonating, Fragment Producing
  - 1.3—Mass Fire
  - 1.4—Moderate Fire, No Blast
- c—Chapter 4 DoD 5154.4S

5-3. Class 1, Division 1 (Mass-Detonating)

Items in this division shall be those for which practically instantaneous explosion or detonation of virtually the entire quantity may be expected. List of items (examples only): Bulk explosives, some propellants, mines, bombs, demolition charges, torpedo and missile warheads, rockets, palletized projectiles loaded with TNT or Comp B, 8-inch and larger high-capacity projectiles loaded with explosive "D", mass-detonating CBU's, and ammunition components having mass-detonating characteristics.

Table 5-3.1 - Class 1, Division 1: Inhabited Building and Public Traffic Route Distances(Ref. Notes)

NEW Over	Not Over	Distance in Feet to Inhabited Building From Standard Earth-Covered Magazine Front or Side	Distance in Feet to Inhabited Building From Standard Earth-Covered Magazine Rear	Distance in Feet to Inhabited Building From Other PES	Distance in Feet to Public Traffic Route From Standard Earth-Covered Magazine Front or Side	Distance in Feet to Public Traffic Route From Standard Earth-Covered Magazine Rear	Distance in Feet to Public Traffic Route From Other PES
0	1	35	25	40	21	15	24
1	2	44	32	50	26	19	30
2	5	60	43	69	36	26	40
5	10	75	54	87	45	32	52
10	20	95	68	110	57	41	65
20	30	110	78	125	65	47	75
30	40	120	86	140	72	51	83
40	50	130	92	150	77	55	89
50	100	160	115	190	97	70	115
100	200	205	145	235	125	88	140
200	300	235	165	270	140	100	160
300	400	260	185	295	155	110	175
400	500	280	200	320	165	120	190
500	600	295	210	340	175	125	205
600	700	310	220	355	185	135	215
700	800	325	230	375	195	140	225
800	900	340	240	390	205	145	235
900	1,000	350	250	400	210	150	240
1,000	1,500	400	285	460	240	170	275
1,500	2,000	440	315	505	265	190	305
2,000	3,000	505	360	580	305	215	350
3,000	4,000	555	395	635	335	240	380
4,000	5,000	600	430	685	360	255	410
5,000	6,000	635	455	730	380	275	440
6,000	7,000	670	480	770	400	285	460
7,000	8,000	700	500	800	420	300	480
8,000	9,000	730	520	835	435	310	500
9,000	10,000	755	540	865	450	325	520
10,000	15,000	865	615	990	520	370	595
15,000	20,000	950	680	1,090	570	405	655
20,000	25,000	1,025	730	1,170	615	440	700
25,000	30,000	1,085	775	1,250	650	465	745
30,000	35,000	1,145	820	1,310	685	490	785
35,000	40,000	1,195	855	1,370	720	515	820
40,000	45,000	1,245	890	1,425	745	535	855
45,000	50,000	1,290	920	1,475	775	555	885
50,000	55,000	1,330	950	1,520	800	570	910
55,000	60,000	1,370	980	1,565	820	585	940
60,000	65,000	1,405	1,005	1,610	845	605	965
65,000	70,000	1,440	1,030	1,650	865	620	990
70,000	75,000	1,475	1,055	1,685	885	635	1,010
75,000	80,000	1,510	1,075	1,725	905	645	1,035
80,000	85,000	1,540	1,100	1,760	925	660	1,055
85,000	90,000	1,570	1,120	1,795	940	670	1,075
90,000	95,000	1,595	1,140	1,825	960	685	1,095

Table 5-3.1 - Class 1, Division 1: Inhabited Building and Public Traffic Route Distances(Ref. Notes)

NEW Over	Not Over	Distance in Feet to Inhabited Building From Standard Earth-Covered Magazine Front or Side	Distance in Feet to Inhabited Building From Standard Earth-Covered Magazine Rear	Distance in Feet to Inhabited Building From Other PES	Distance in Feet to Public Traffic Route From Standard Earth-Covered Magazine Front or Side	Distance in Feet to Public Traffic Route From Standard Earth-Covered Magazine Rear	Distance in Feet to Public Traffic Route From Other PES
95,000	100,000	1,625	1,160	1,855	975	695	1,115
100,000	110,000	1,740	1,290	1,960	1,045	770	1,175
110,000	120,000	1,855	1,415	2,065	1,110	850	1,240
120,000	125,000	1,910	1,480	2,115	1,145	890	1,270
125,000	130,000	1,965	1,545	2,165	1,180	925	1,300
130,000	140,000	2,070	1,675	2,255	1,245	1,005	1,355
140,000	150,000	2,175	1,805	2,350	1,305	1,085	1,410
150,000	160,000	2,280	1,935	2,435	1,370	1,160	1,460
160,000	170,000	2,385	2,070	2,520	1,430	1,240	1,515
170,000	175,000	2,435	2,135	2,565	1,460	1,280	1,540
175,000	180,000	2,485	2,200	2,605	1,490	1,320	1,565
180,000	190,000	2,585	2,335	2,690	1,550	1,400	1,615
190,000	200,000	2,680	2,470	2,770	1,610	1,480	1,660
200,000	225,000	2,920	2,810	2,965	1,750	1,685	1,780
225,000	250,000	3,150	3,150	3,150	1,890	1,890	1,890
250,000	275,000	3,250	3,250	3,250	1,950	1,950	1,950
275,000	300,000	3,345	3,345	3,345	2,005	2,005	2,005
300,000	325,000	3,440	3,440	3,440	2,065	2,065	2,065
325,000	350,000	3,525	3,525	3,525	2,115	2,115	2,115
350,000	375,000	3,605	3,605	3,605	2,165	2,165	2,165
375,000	400,000	3,685	3,685	3,685	2,210	2,210	2,210
400,000	425,000	3,760	3,760	3,760	2,250	2,250	2,250
425,000	450,000	3,830	3,830	3,830	2,300	2,300	2,300
450,000	475,000	3,900	3,900	3,900	2,340	2,340	2,340
475,000	500,000	3,970	3,970	3,970	2,380	2,380	2,380

Notes:

1. Distances are computed using following factors:

NEW	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8
0 - 100,000	$35W^{1/3}$	$25W^{1/3}$	$40W^{1/3}$	$21W^{1/3}$	$15W^{1/3}$	$24W^{1/3}$
100,000 - 250,000	$0.3955W^{0.7227}$	$.004125W^{1.0898}$	$2.42W^{0.577}$	$.2375W^{0.7227}$	$.002475W^{1.0898}$	$1.452W^{0.577}$
250,000 - 15,000,000	$50W^{1/3}$	$50W^{1/3}$	$50W^{1/3}$	$30W^{1/3}$	$30W^{1/3}$	$30W^{1/3}$

2. The policy contained in para 5-2F shall be employed for mass-detonating fragment producing items.
3. The distances for 0 to 50 lbs. may be used only when structures, blast mats, etc., can completely confine fragments and debris. Lesser distances may only be used if blast, fragments, and debris can be completely confined as in certain test firing barricades.
4. Applies only to earth-covered magazines with dimensions of 26 feet wide and 60 feet long, or larger.

Table 5-3.2 - Minimum Fragment Protection Distances for Selected Class 1, Division 1 Items.[1]

Nomenclature	Distance required in Feet			
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5
	1 Unit	2 Units	4 Units	16 Units[2]
Bomb, 750 lb. M117A2	690	830	1090	1470
Bomb, 500 lb., Mk82	670	860	1080	1240
Projectile, 175mm, M437A2	450	580	830	2070
Projectile, 155mm, M107	400	510	720	1490
Projectile, 105mm, M1[3]	270	350	500	1000
Projectile, 8 in, Mk25	530	750	990	1240
Projectile, 8 in, Mk 49	280	430	660	1000
Torpedoes (Navy) Not Over 1500 lbs NEW	500[4]	500[4]	500[4]	500[4]

NOTE

[1] Reference paragraph 5-2C.

[2] 105mm projectiles and 105mm complete rounds not in standard storage and shipping containers are Class 1, Division 1 ammunition.

[3] 10 units or more until the point is reached at which this distance is exceeded by the distance requirements of Table 5-3.1, Column 3.

[4] This distance applies to any torpedoes that are analogous in terms of explosive hazard to those tested; i.e., MK 16 war shot.

TABLE 5-3.3—*Class 1, Division 1: Intraline Distances*

NEW		Distances in Feet		NEW		Distances in Feet	
Over	Not Over	Barr $D = 9W^{1/3}$	Unbarr $D = 18W^{1/3}$	Over	Not Over	Barr $D = 9W^{1/3}$	Unbarr $D = 18W^{1/3}$
Col. 1	Col. 2	Col. 3	Col. 4	Col. 1	Col. 2	Col. 3	Col. 4
0	50[1]	30	60	65,000	70,000	370	740
50	100	40	80	70,000	75,000	380	760
100	200	50	100	75,000	80,000	390	780
200	300	60	120	80,000	85,000	395	790
300	400	65	130	85,000	90,000	405	810
400	500	70	140	90,000	95,000	410	820
500	600	75	150	95,000	100,000	420	840
600	700	80	160	100,000	125,000	450	900
700	800	85	170	125,000	150,000	480	960
800	900	85	175	150,000	175,000	505	1,010
900	1,000	90	180	175,000	200,000	525	1,055
1,000	1,500	105	210	200,000	225,000	545	1,090
1,500	2,000	115	230	225,000	250,000	565	1,135
2,000	3,000	130	260	250,000	275,000	585	1,170
3,000	4,000	145	290	275,000	300,000	600	1,200
4,000	5,000	155	310	300,000	325,000	620	1,240
5,000	6,000	165	330	325,000	350,000	635	1,270
6,000	7,000	170	340	350,000	375,000	650	1,300
7,000	8,000	180	360	375,000	400,000	665	1,330
8,000	9,000	185	370	400,000	500,000[2]	715	1,430
9,000	10,000	195	390	500,000	600,000	760	1,520
10,000	15,000	225	450	600,000	700,000	800	1,600
15,000	20,000	245	490	700,000	800,000	835	1,670
20,000	25,000	265	530	800,000	900,000	870	1,740
25,000	30,000	280	560	900,000	1,000,000	900	1,800
30,000	35,000	295	590	1,000,000	1,500,000	1,030	2,060
35,000	40,000	310	620	1,500,000	2,000,000	1,135	2,270
40,000	45,000	320	640	2,000,000	2,500,000	1,220	2,440
45,000	50,000	330	660	2,500,000	3,000,000	1,300	2,600
50,000	55,000	340	680	3,000,000	3,500,000	1,365	2,730
55,000	60,000	350	700	3,500,000	4,000,000	1,420	2,860
60,000	65,000	360	720	4,000,000	5,000,000	1,540	3,080

NOTES:

[1] For less than 50 pounds, less distances (determined by formulas for Columns 3 & 4) may be used when structures, blast mats, etc., can completely contain fragments and debris. This table is not applicable when blast, fragments, and debris are completely confined as in certain test firing barricades.

[2] Quantities above 500,000 lbs NEW are authorized only for Group IV liquid propellants (Reference paragraph 5-16D).

Table 5-3.4 - Class 1, Division 1: Intermagazine Hazard Factors and Distances. Use With Table 5-3.5 - (for application see para. 5-4)

NEW

Over	Not Over	$1.1W^{1/3}$	$1.25W^{1/3}$	$2W^{1/3}$	$2.75W^{1/3}$	$4.0W^{1/3}$	$4.5W^{1/3}$	$5W^{1/3}$	$6W^{1/3}$	$8W^{1/3}$	$11W^{1/3}$
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10	Col 11	Col 12
0	100	7	7	9	13	18	21	24	28	36	51
100	200	7	7	12	16	24	26	30	35	48	64
200	300	7	8	13	18	26	30	32	40	52	74
300	400	8	9	15	20	30	33	36	44	60	81
400	500	9	10	16	22	32	36	40	48	64	87
500	600	9	11	17	23	34	38	44	51	68	93
600	700	10	11	18	24	36	40	44	53	72	98
700	800	10	12	19	26	38	42	48	56	76	102
800	900	11	12	19	27	38	43	48	58	76	106
900	1,000	11	13	20	28	40	45	50	60	80	110
1,000	1,500	13	14	23	31	46	52	56	69	92	126
1,500	2,000	14	16	25	34	50	57	64	76	100	139
2,000	3,000	16	18	29	40	58	65	72	86	116	158
3,000	4,000	17	20	32	44	64	72	80	95	128	175
4,000	5,000	19	21	34	47	68	77	84	103	136	188
5,000	6,000	20	23	36	50	72	82	92	109	144	200
6,000	7,000	21	24	38	53	76	86	96	115	152	210
7,000	8,000	22	25	40	55	80	90	100	120	160	220
8,000	9,000	23	26	42	57	84	94	104	125	168	230
9,000	10,000	24	27	43	59	86	97	108	130	172	235
10,000	20,000	30	35	55	75	110	120	140	165	220	300
20,000	30,000	35	40	60	85	120	140	160	185	240	340
30,000	40,000	40	45	70	95	140	150	170	205	280	375
40,000	50,000	40	45	75	100	150	170	180	220	300	405
50,000	60,000	45	50	80	110	160	180	200	235	320	430
60,000	70,000	45	50	80	115	160	185	210	245	320	455
70,000	80,000	45	55	85	120	170	195	220	250	340	475
80,000	90,000	50	55	90	125	180	200	220	270	360	495
90,000	100,000	50	60	95	130	190	210	230	280	380	510
100,000	125,000	55	65	100	140	200	225	250	300	400	550
125,000	150,000	60	65	105	145	210	240	260	320	420	585

Table 5-3.4 - Class I, Division 1: Intermagazine Hazard Factors and Distances. Use With Table 5-3.5 - (for application see para. 5-4)

NEW

Over	Not Over	$1.1W^{1/3}$	$1.25W^{1/3}$	$2W^{1/3}$	$2.75W^{1/3}$	$4.0W^{1/3}$	$4.5W^{1/3}$	$5W^{1/3}$	$6W^{1/3}$	$8W^{1/3}$	$11W^{1/3}$
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10	Col 11	Col 12
150,000	175,000	60	70	110	155	220	250	280	335	440	615
175,000	200,000	65	75	115	160	230	260	290	350	460	645
200,000	225,000	65	75	120	165	240	270	300	365	480	670
225,000	250,000	70	80	125	175	250	285	320	380	500	695
250,000	300,000	75	85	135	185	270	300	340	400	540	735
300,000	350,000	80	90	140	195	280	320	350	425	560	775
350,000	400,000	80	90	145	205	290	330	370	440	580	810
400,000	450,000	85	95	155	210	310	345	380	460	620	845
450,000	500,000	85	100	160	220	320	360	400	475	640	875
500,000	600,000	95	105	170	230	340	380	420	505	680	930
600,000	700,000	100	110	180	245	360	400	440	535	720	975
700,000	800,000	100	115	185	255	370	420	460	555	740	1,020
800,000	900,000	105	120	195	265	390	435	480	580	780	1,060
900,000	1,000,000	110	125	200	275	400	450	500	600	800	1,100
1,000,000	1,250,000	120	135	215	295	430	485	540	645	860	1,185
1,250,000	1,500,000	125	145	230	315	460	515	570	685	920	1,260
1,500,000	1,750,000	135	150	240	330	480	540	600	725	960	1,325
1,750,000	2,000,000	140	160	250	345	500	570	630	755	1,000	1,385
2,000,000	2,250,000	145	165	260	360	520	590	660	785	1,040	1,440
2,250,000	2,500,000	150	170	270	375	540	610	680	815	1,080	1,495
2,500,000	2,750,000	155	175	280	385	560	630	700	840	1,120	1,540
2,750,000	3,000,000	160	180	290	395	580	650	720	865	1,160	1,585
3,000,000	3,250,000	165	185	295	405	590	670	740	890	1,180	1,630
3,250,000	3,500,000	165	190	305	415	610	680	760	910	1,220	1,670
3,500,000	3,750,000	170	195	310	430	620	700	780	930	1,240	1,710
3,750,000	4,000,000	175	200	315	435	630	715	790	950	1,260	1,745
4,000,000	4,250,000	180	200	325	445	650	730	810	970	1,300	1,780
4,250,000	4,500,000	180	205	330	455	660	740	830	990	1,320	1,815
4,500,000	4,750,000	185	210	335	460	670	760	840	1,010	1,340	1,850
4,750,000	5,000,000	190	215	340	470	680	770	860	1,025	1,360	1,880
5,000,000	5,500,000	195	220	355	485	710	795	880	1,060	1,420	1,940
5,500,000	6,000,000	200	225	365	500	730	820	890	1,090	1,460	2,000
6,000,000	6,500,000	205	235	375	515	750	840	930	1,120	1,500	2,055
6,500,000	7,000,000	210	240	385	525	770	860	960	1,150	1,540	2,105
7,000,000	7,500,000	215	245	390	540	780	880	980	1,175	1,560	2,155
7,500,000	8,000,000	220	250	400	550	800	900	1,000	1,200	1,600	2,200
8,000,000	8,500,000	225	255	410	560	820	920	1,020	1,225	1,640	2,245
8,500,000	9,000,000	230	260	415	570	830	935	1,040	1,250	1,660	2,290
9,000,000	9,500,000	235	265	425	580	850	950	1,060	1,270	1,700	2,330
9,500,000	10,000,000	235	270	430	595	860	970	1,080	1,295	1,720	2,370
10,000,000	11,000,000	245	280	445	610	890	1,000	1,110	1,335	1,780	2,415
11,000,000	12,000,000	250	285	460	630	920	1,030	1,140	1,375	1,840	2,520
12,000,000	13,000,000	260	295	470	645	940	1,060	1,160	1,410	1,880	2,585
13,000,000	14,000,000	265	300	480	665	960	1,085	1,210	1,445	1,920	2,640
14,000,000	15,000,000	270	310	495	680	990	1,110	1,230	1,480	1,980	2,715

Table 5-3.5 - Class 1, Division 1: Guide for Intermagazine Distance Table.
Numbers at intersections identify columns of Table 5-3.4.

From \ To		1. Std. Earth Covered Magazine (a)				2. Non-Std. Earth-Covered Magazine (b)				3. Above ground Mag. (Not earth covered) (c)		4. Modules	
												Module	Cell
		a. Side	b. Rear	c. Front-Unbarricaded	d. Front-Barricaded	a. Side	b. Rear	c. Front-Unbarricaded	d. Front-Barricaded	a. Unbarricaded	b. Barricaded	a. Barricaded	b. Barricaded
1. Std. Earth Covered Magazine (a)	a. Side	4	4	6	6	4	4	10	10	10	8[e]	4	4
	b. Rear	4	4	5	5	4	4	10	10	10	8[e]	4	4
	c. Front Unbarricaded	6	5	(d)	(d)	6	5	12	10	12	10	10	10
	d. Front Barricaded	6	5	(d)	(d)	6	5	10	10	10	10	10	10
2. Non-standard Earth-Covered Magazine (b)	a. Side	4	4	6	6	4	4	10	10	10	10	4	4
	b. Rear	4	4	5	5	4	4	10	10	10	10	4	4
	c. Front Unbarricaded	10	10	12	10	10	10	12	10	12	10	10	10
	d. Front Barricaded	10	10	10	10	10	10	10	10	10	10	10	10
3. Above-ground Mag. (not earth covered)(c)	a. Unbarricaded	7	7	12	10	7	7	12	10	12	10	10	10
	b. Barricaded	7	7	10	10	7	7	10	10	10	10	10	10
4. Module Cell Module	a. Barricaded	4	4	10	10	4	4	10	10	10	10	3	3
	b. Barricaded	4	4	10	10	4	4	10	10	10	10	3	3

NOTES:
(a) Standard Earth-Covered Magazines consist of all magazines equal to or greater in strength to those enumerated in paragraphs 3-4A1, B1, and C.
(b) Non-standard, Earth-Covered Magazines except those in note (a) above, with earth cover equal to or greater than that required by Standard, Earth-Covered Magazines.
(c) Aboveground Magazines are all types abovegrade (not earth-covered) magazines or storage pads.
(d) Reference para 5-4.
(e) Separation distance of 125 ft. is authorized where earth-covered magazine contains only class 1 division 2.

5-4. Application of Intermagazine Distances for Class 1 Division 1 Only

A. In applying the intermagazine distances given in table 5-3.4, consideration must be given to magazine construction and to the orientation of the magazines to each other. To determine the proper earth-covered magazine separation distances, the following conditions apply:

1. When standard earth-covered magazines containing class 1, division 1 ammunition are sited so that any one is in the forward sector 60° either side of the centerline of another, the two must be separated by distances greater than the minimum permitted for side-to-side orientations. The greater distances are required primarily for the protection of door and headwall structures against blast from a potential explosion site forward of the exposed magazine, and to a lesser extent due to the directionality of effects from the source. When a blast wave is reflected from a surface at other than grazing incidence (side-on orientation), the overpressure may be increased substantially over the free-field value. High reflected pressure and impulse can damage doors and headwalls and propel the debris into the igloo so that explosion is communicated by impact of such debris upon the contents. Permitting some significant (but oblique) unbarricaded headwall-to-headwall exposure at reduced intermagazine distances constitutes a relaxation of conditions that have been proved safe by test. Some examples of the application of these rules follow:

a. If headwalls of both A and B are outside the 120° sector (60° either side of the centerline), they may be separated by the column 4 distances based on the largest quantity of class 1, division 1 stored in either. This is considered the equivalent of standard side-to-side separation with the optimum orientation—all igloos facing the same direction and axes parallel (see figures 5-4.1 and 5-4.2).

b. If headwall of A is outside of the 120° sector of B, but headwall of B is inside the 120° sector of A, separation distance between these two igloos is determined by column 7 based on the largest quantity of class 1, division 1 in either igloo. For existing igloos originally sited at column 4 based upon the content of either igloo, this arbitrary application could result in an unwarranted penalty as regards the limit on A (see figure 5-4.3).

c. With comparable explosive quantities in A and B, it is the exposure of igloo A to an explosion in B that necessitates application of column 7 distances. If the quantity in B were reduced to less than one-tenth of that in A, or if the storage in B is not class 1 division 1, igloo A would control as a potential explosion site. In accordance with paragraph 3-2, the quantity-distance requirement must then be taken from column 4 applied to the quantity in A; that is, the quantity in A would not need to be reduced. Therefore, basing the explosive limit in A upon column 4 toward B is not considered a deviation from the standard and does not require a waiver or exemption (see figure 5-4.3).

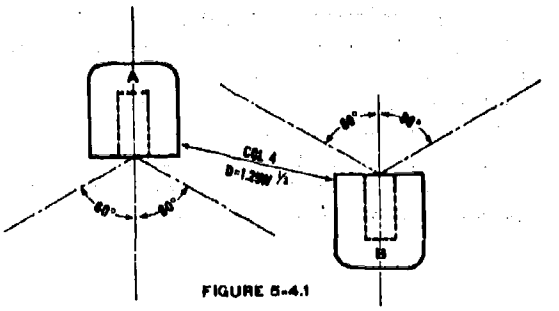


FIGURE 5-4.1

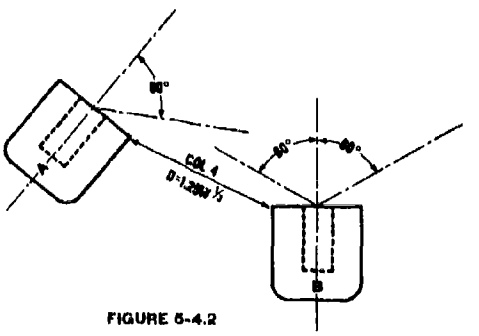


FIGURE 5-4.2

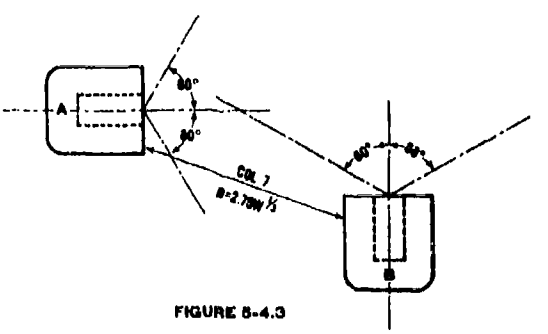


FIGURE 5-4.3

d. If headwalls of A and B are within the 120° sector of each other and are not provided with a separate door barricade, column 9, table 5-3.4 distances must be used to separate them. If one or more separate door barricades are present (meeting requirements of paragraph 3-4E) such as A to C, then column 8 distances may be used to determine separation distances (see figure 5-4.4).

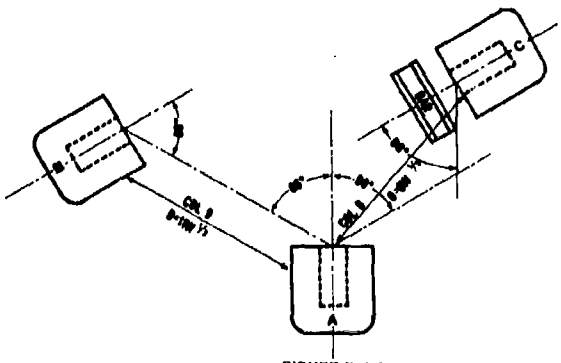


FIGURE 5-4.4

e. Although no separate barricade is shown between A and B, more detailed analysis of a specific storage condition of this type might show that the distribution of explosives within A and B is such that the earth fill of one or the other or both meets the specifications of an effective barricade according to paragraph 3-4E. In such a case, column 8 distances would apply between A and B (see figure 5-4.4).

f. Two additional standard igloo orientations warrant analysis. These are:

(1) Igloos A and B are either of significantly different length or "canted" in such a manner that one of them is within the 120° sector off the headwall of the other, even though a straight line between headwall A and igloo B does pass through the earth cover of B (see figure 5-4.5).

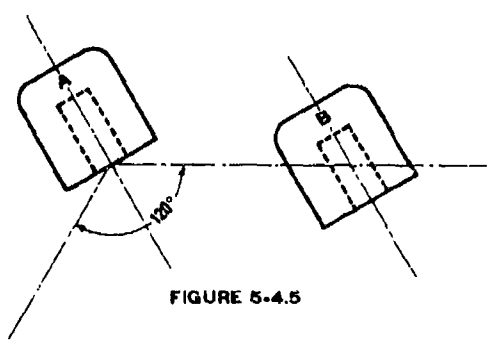


FIGURE 5-4.5

(2) If B is the potential explosion site and A is the exposed site, the limit for B would be determined by column 7. With A as the potential explosion site, however, the limit for A would be based upon column 4. Igloo B may be used to its physical capacity for hazard divisions other than 1.1 (see figure 5-4.6).

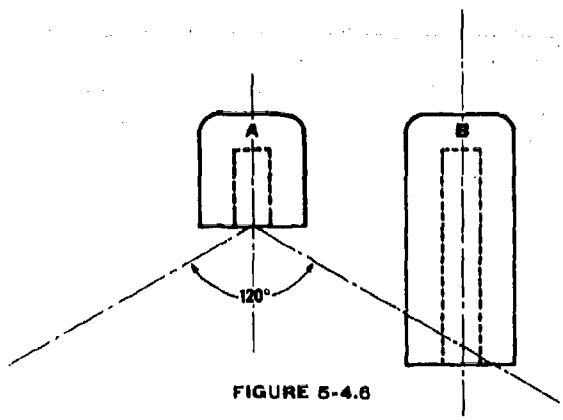


FIGURE 5-4.6

2. When considering relationships between standard earth-covered magazines and aboveground magazines, or facilities requiring intraline distances each containing class 1, division 1 ammunition or explosives, the question regarding the use of barricaded or unbarricaded distances arises. The following criteria will apply:

a. Aboveground magazines, or facilities requiring intraline distances, that are within the 120° sector off the front of a standard earth-covered magazine will be provided unbarricaded distances unless a separate effective intervening barricade meeting requirements of paragraph 3-4E is present, in which case barricaded distances may be applied (see figure 5-4.7).

b. Aboveground magazines, or facilities requiring intraline distances, that are outside of the 120° sector off the front of a standard earth-covered magazine will be provided with barricaded distances whether or not a separate intervening barricade is present (see figure 5-4.7).

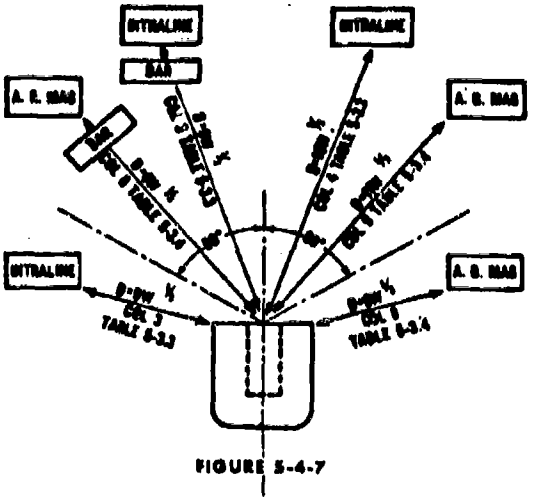


FIGURE 5-4-7

B. Distances in column 4 apply to magazines, earth-covered, non-standard when the magazines are so oriented that all straight lines between the sides and rear walls of two magazines pass through an earth-covered surface of each; similarly, column 8 distances apply to all orientations in which every straight line between two magazines passes through the earth cover of one and only one of them. If the above conditions cannot be met, column 9 distances apply. The earth cover of non-standard magazines must be equal to or greater than that required for standard earth-covered, arch-type magazines.

C. Other factors limiting igloo magazine storage are:

1. Igloo magazines which are equivalent in strength to the requirements of paragraphs 3-4A1, B1, and C are limited to 500,000 lbs NEW. Igloo magazines not equivalent in strength to the requirements of paragraphs 3-4A1, B1, or C are limited to 250,000 lbs NEW.

2. Quantities above 500,000 lbs NEW in one storage location are not authorized except for liquid propellants.

3. The distance given for 0 to 100 lbs NEW constitutes the minimum magazine spacing permitted.

D. Examples given in paragraphs 5-4A.1.a through 5-4A.1.f above apply only to the storage of class 1, division 1 ammunition and explosives. Existing earth-covered magazines, regardless of orientation, meeting the construction and barricading requirements of chapters 3 and 5 (and sited for any quantity of class 1, division 1) may be used to their physical capacity for the storage of class 1, divisions 2, 3, and 4 ammunition and explosives.

5-5. Class 1, Division 2 (Non Mass-Detonating, Fragment Producing)

A. Items in this division are those for which the principal hazards are fragment and blast, either individually or in combination, depending on such factors as storage configuration, type of packing, and quantity. The designated minimum distances which are specified are based on the limiting range of fragments for which protection by distance is to be provided and shall be used for Inhabited Building and Public Traffic Route distances. Most fragments produced by incidents in this division will fall within one of the four specified minimum distances; i.e., 400, 800, 1200 and 1800 feet. Because fragment producing types can be grouped according to the range of fragments produced, four fragment distance categories are established to permit flexibility of storage.

B. The fragment hazard from items within a specified minimum distance category varies with existing conditions, but is essentially the same for one as for many items or components. For these items the required separation distances are influenced heavily by packing, state of assembly, charge-weight ratio, and caliber. Items in this division usually explode progressively when involved in a fire or otherwise initiated. Therefore, the distances prescribed shall not be lessened if the quantity to be stored is less than the maximum quantity specified by the appropriate table.

Class 1, Division 2((04)1.2)

Table 5-5.1 - Category (04), Class 1, Division 2(Ref. Note 1)

NEW	Inhabited Building Distance (feet)	Public Traffic Route Distance(feet)	Intraline Distance (feet)	Magazine Distance(feet) Aboveground	Magazine Distance(feet) Earth-covered
Col. 1	Col. 2	Col.3	Col. 4	Col. 5	Col. 6
No limit specifically required for safety reasons	400	240	200	200[2]	Ref. Note 3

List of items (examples only): Small arms ammunition with explosive projectiles; 20mm ammunition with explosive projectiles; fixed ammunition with non-explosive projectiles when caliber and packing limit the hazard in accordance with this class; WP smoke hand grenades; and non-mass detonating CBU's[3].

NOTES:

1 Limited quantities of items in this class, for reasons of operational necessity, may be stored in facilities such as hangars, troop buildings, and manufacturing or operating buildings without regard to quantity-distance, e.g., small destructors, fuzes, and firing devices.

2 Reference paragraph 3-4D for module storage criteria.

3 Earth-covered buildings may be used to their physical capacity for this category of material provided they comply with the construction and siting requirements of chapters 3 and 5 for class 1 division 1 material.

Class 1, Division 2,((08)1.2)

Table 5-5.2 - Category(08), Class 1, Division 2

NEW	Inhabited Building Distance (feet)	Public Traffic Route Distance(feet)	Intraline Distance (feet)	Magazine Distance(feet) Aboveground	Magazine Distance(feet) Earth-covered
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
No limit specifically required for safety reasons	800	480	400[1]	300[2]	Ref. Note 3

List of items (examples only): Fixed and semifixed ammunition, rockets and rocket components, chemical ammunition containing explosive elements and non-mass-detonating CBU's.[3]

NOTE:

1 If the H.E. in(08)1.2 items at an operating line PES is limited to 5000 lbs., intraline distance may be reduced to 200 ft.

2 Reference paragraph 3-4D for module storage criteria.

3 Earth-covered buildings may be used to their physical capacity for this category of material provided they comply with the construction and siting requirements of chapters 3 and 5 for class 1 division 1 material.

Class 1, Division 2,((12)1.2)

Table 5-5.3 - Category(12), Class 1, Division 2[1]

NEW	Inhabited Building Distance (feet)	Public Traffic Route Distance(feet)	Intraline Distance (feet)	Magazine Distance(feet)	
				Aboveground	Earth-covered
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
500,000	1,200	720	600[2]	300[3]	Ref. Note 4

List of items (examples only): Separate projectiles with explosive "D" filler, except high capacity types, caliber 8 inch or larger; fixed and semifixed ammunition; non-mass detonating cluster bomb units(CBU); rockets, rocket motors and non mass-detonating rocket heads; and chemical ammunition containing explosive components.
NOTES:

1 Items of this category present a risk of propagation to adjacent aboveground magazines, particularly when packed in combustile containers. Storage in earth-covered magazines is therefore preferred.

2 If the H.E. in(12)1.2 items at an operating line PES is limited to 5000 lbs., intraline distance may be reduced to 200 ft.

3 Reference paragraph 3-4D for module storage criteria.

4 Earth-covered buildings may be used to their physical capacity for this class of material provided they comply with the construction and siting requirements of chapters 3 and 5 for class 1 division 1 material.

Class 1, Division 2,((18)1.2)

Table 5-5.4 - Category(18), Class 1, Division 2[1 2]

NEW	Inhabited Building Distance (feet)	Public Traffic Route Distance(feet)	Intraline Distance (feet)	Magazine Distance(feet)	
				Aboveground	Earth-covered
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
500,00	1,800	1,080	900	300	Ref. Note 2

List of items (examples only): Non-mass detonating H.E. loaded projectiles; fixed and semifixed ammunition; rockets and rocket heads.
NOTES:

1 Items of this category present a risk of propagation to adjacent aboveground magazines, particularly when packed in combustible containers. Storage in earth-covered magazines is therefore preferred.

2 Earth-covered buildings may be used to their physical capacity for this category of material provided they comply with the construction and siting requirements of chapters 3 and 5 for class 1 division 1 material.

5-6. Class 1, Division 3 (Mass Fire)

Items in this division are those which burn vigorously with little or no possibility of extinguishment in storage situations. Explosions normally will be confined to pressure ruptures of containers and will not produce propagating shock waves or damaging blast overpressure beyond the magazine distance specified in Table 5-6.1. A severe hazard of the spread of fire may result from tossing about of burning container materials, propellant, or other flaming debris.

Table 5-6.1 - Class 1, Division 3[1] [2]

NEW (Over)	NEW (not over)	Inhabited Building Distance (feet)	Public Traffic Route Distances (feet)	Magazine Distance	
				Above ground Magazine Intraline (feet)	Earth-covered (feet)
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
0	1,000	75	75	50	Ref. Note 3
1,000	5,000	115	115	75	
5,000	10,000	150	150	100	
10,000	20,000	190	190	125	
20,000	30,000	215	215	145	
30,000	40,000	235	235	155	
40,000	50,000	250	250	165	
50,000	60,000	260	260	175	
60,000	70,000	270	270	185	
70,000	80,000	280	280	190	
80,000	90,000	295	295	195	
90,000	100,000	300	300	200	
100,000	200,000	375	375	250	
200,000	300,000	450	450	300	
300,000	400,000	525	525	350	
400,000	500,000	600	600	400	
500,000	1,000,000	800	800	500	

For determining distances to be used in event special requirements exist for amounts above 1,000,000 lbs. the values given above will be extrapolated by means of cube-root scaling as follows:

For inhabited building, and public traffic route distances..... $D = 8W^{1/3}$

For aboveground magazine and intraline distances..... $D = 5W^{1/3}$

List of items(examples only): Military pyrotechnics; solid propellants in bulk, in containers, or in ammunition items; non-toxic chemical ammunition.

Notes:

[1] Items will be placed in this class if they qualify for assignment to it after evaluation in accordance with chapter 4 and para 5-2.

[2] Limited quantities of items in this class, for reasons of operational necessity, may be stored in facilities such as hangers, troop buildings, and manufacturing or operating buildings without regard to quantity-distance; e.g., document destruction and signaling devices, and riot control munitions.

[3] Earth-covered buildings may be used to their physical capacity for this division provided they comply with the construction and siting requirements of chapters 3 and 5 for class 1 division 1 material.

5-7. Class 1, Division 4 (Moderate Fire, No Blast)

A. Items in this division are those which present a fire hazard with no blast hazard and virtually no fragmentation or toxic hazard beyond the fire hazard clearance ordinarily specified for high-risk materials. Separate facilities for storage and handling of this division should not be less than 100 feet from other facilities except that, if of fire-resistive construction, they may be 50 feet from each other.

B. Articles containing about 1 oz or less of explosives and classified based on test results as 1.4S may be considered as inert for storage purposes and are not subject to part 173 title 49 CFR for transport. Articles containing larger quantities of explosives, but also classified as 1.4S based upon tests may be considered inert for storage purposes but must be reviewed on an individual basis to determine if part 173 title 49 CFR is to be applied for transport.

Table 5-7.1 - Class 1, Division 4[1]

NEW	Inhabited Building Distance (feet)	Public Traffic Route Distance (feet)	Intraline Distance (feet)	Magazine Distance (feet)	
				Aboveground	Earth-covered
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
Limited quantities[2]	.....	.....	.....	.....	.....
Larger quantities no limit specifically required for safety reasons	100	100	50(100 if combustible construction)	50(100 if combustible construction)	No specified separation requirement.

List of items (examples only): Small arms ammunition without explosive projectiles, fuse lighters and squibs, distress signals, 20mm ammunition without explosive projectiles, colored smoke grenades, and explosive valves or switches. Reference 4-4D12.

NOTES:

[1] With reasonable care in storage, Class 1, Division 4 items may be stored in any weatherproof warehouse in a warehouse area for general supplies provided such warehouses used for the storage of Division 4 ammunition are separated from all other warehouses by at least the aboveground magazine separation distance specified.

[2] Limited quantities of Class 1, Division 4 items may be stored in facilities such as hangars, troop buildings, and manufacturing or operating buildings without regard to quantity distance, e.g., small arms ammunition, riot control munitions, and pyrotechnics for alert or security purposes. Also, small magazines for essentially the same usage may be separated by appropriate fire protection distances.

ployees performing such work, the protection of other employees at the installation who are not associated with such work, and the protection of the general public outside the installation. Personnel responsible for planning, designing, and accomplishing such operations must assure that adequate safety is provided by incorporating the appropriate types of hazard containment. (To this end, the risk assessment and hazard analysis methodology set forth in Military Standard 882A, "System Safety Program Requirements," June 28, 1977, should be considered.) The various circumstances and facilities that may be encountered at such operations prevent pre-definition in this standard of specific detailed containment requirements for each agent, each ammunition item, and each operation. Nevertheless, the general principles of hazard containment set forth below will be normally incorporated in operations such as manufacture, disassembly, demilitarization, and disposal.

2. There are two types of containment: "total containment," and "vapor containment." Irrespective of which type of containment is provided, the containment structure or facility will be equipped with a means of entrapping or detoxifying the evaporated or aerosolized chemical agent by filters, scrubbers, incinerators, or other appropriate means. Total containment and vapor containment are described as follows:

a. Total containment requires a facility designed and tested to be of sufficient capacity and strength to contain combustion or detonation gases, fragments, and agent from the largest explosion that could occur, based upon the propagation characteristics of the ammunition. Currently, there are two basic designs for such total containment. One design consists of a chamber capable of retaining all of the fragments and explosion effects; and preventing release of detectable quantities of agent.

b. Vapor containment will consist of a facility designed to provide negative pressure, controlled air flow, and walled or multiple walled enclosures which will contain any detectable quantities of agent released. Designs for vapor containment are usually tailored to the operation involved.

3. Containment is not required for operations associated with storage activities. Examples of such operations include shipping, storing, receiving, rewarehousing, minor maintenance, surveillance inspection, repair, and encapsulation. Emergency agent transfer in the event of agent leakage is also permitted without containment. These activities normally present an acceptable degree of safety except in the event of an agent leaker, and then the increased hazard is only to those operating personnel in proximity. In the event of a leaker, measures such as personal protective clothing and equipment are mandatory to protect operating personnel during the application of decontamination procedures to neutralize the escaping agent, and to repair, encapsulate, or transfer agent from the leaking ammunition or container.

4. The selection of the type of containment is dependent upon the nature of the operation involved. Total containment is required for those operations involving ammunition which contain explosive components as well as toxic agents, whenever the operation may subject the explosive components to a potential initiating stimulus. Vapor containment is required for those operations involving toxic agents in bulk or in ammunition without explosives components; and for those operations involving ammunition containing both toxic agent and explosive components wherein the operation does not subject the explosive components to a potential initiating stimulus. Examples of disassembly, demilitarization, and disposal operations which normally require total containment and those which require vapor containment are listed below. For situations not specifically listed, selection of the type of containment required will be in accordance with the above principles.

a. Operations requiring total containment include:

(1) Machine tool operations; e.g., cutting, sawing, milling, drilling, punching, or shearing of ammunition if the operation requires the cutting tool to remove or displace metal before or after contact with the explosives.

(2) Situations in which the ammunition arming and functioning environments can be duplicated by the sequence of operations and process machinery.

(3) Disassembly of armed or possibly armed ammunition.

(4) Disassembly of explosive components from ammunition where there is evidence of significant damage, exudation of explosives, corrosion, or deterioration; unless testing, analysis or evaluation by DDESB determines that total containment is not required.

(5) Disassembly of explosive components from ammunition where undue force is required to accomplish the disassembly: e.g., where tools used

for disassembly must apply significantly greater leverage or torque than those which were used for the assembly.

b. Operations requiring vapor containment are:

(1) Machine tool operations; e.g., punching, drilling, or sawing of ammunition to remove the agent provided the equipment is designed to prevent contact of its cutting tool with explosives.

(2) Burster well removal, after removal of explosive components.

(3) Transfer of agent from bulk storage tanks, containers, or ammunition into holding tanks, chemical detoxification reactors, incinerators, or similar processing equipment, such as may be found in a production, demilitarization or disposal line. This is not to be construed as requiring vapor containment for agent transfer during field operations involving leaker repair activities (see paragraph 5-7.H.3).

CHAPTER 6

QUANTITY-DISTANCE STANDARDS AND POLICIES FOR AIRFIELDS, HELIPORTS, AND SEADROMES

6-1. Scope

A. This chapter contains quantity-distance standards and policies to be used for airfields, heliports, and seadromes where ammunition and explosives are or may be present and which are—

1. owned and used exclusively by DoD Components;

2. owned by DoD Components but used jointly by DoD/non-DoD interests; or

3. not owned by DoD Components but used jointly by DoD/non-DoD interests.

B. The provisions of this chapter do not apply to explosives items installed on aircraft or contained in survival and rescue kits such as signals, flares, egress systems components, squibs and detonators for jettisoning external stores, engine starter cartridges, fire extinguisher cartridges, destructors in electronic equipment, explosives components of emergency kits and equipment, and other such items or materials necessary for safe flight operations.

6-2. Standards and Policies

A. General. The controlling DoD Component shall assure that these quantity-distance standards are applied:

1. To any airfields, heliports, or seadromes used by DoD Components at which ammunition and explosives are handled or stored.

2. In conjunction with airfield clearance criteria as prescribed by DoD Components, and Federal Aviation Regulation (14 CFR 77), as indicated below:

a. For airfields, heliports, and seadromes used exclusively by DoD Components, combat aircraft parking areas, ammunition and explosives cargo areas, alert hangars, and shelters may be located within the airfield clearance zone insofar as these quantity-distance standards are concerned, except in the explosives prohibited areas as described in paragraph D, below.

b. For airfields, heliports, and seadromes not used exclusively by DoD Components, combat aircraft parking areas, ammunition and explosives cargo areas, alert hangars, and shelters shall be located as prescribed in Tables 6-3.1 and 6-3.2.

c. For aircraft passenger transport operations at airfields, heliports, and seadromes used exclusively by DoD Components, such operations shall be made subject to the same quantity-distance requirements as for airfields, heliports, and seadromes used jointly by DoD Components and non-DoD interests.

3. In separating ammunition and explosives facilities from inhabited buildings, public traffic routes, and other ammunition and explosives facilities in accordance with Chapters 5 and 8.

B. *Measurement of Separation Distances.* In applying the standards prescribed in Tables 6-3.1 and 6-3.2, distances shall be measured as follows:

1. Loaded Aircraft to Loaded Aircraft. Measure the shortest distance between explosives on one aircraft to explosives on adjacent aircraft.

2. Ammunition and Explosives Location to Taxiways and Runways. Measure from the nearest point of the ammunition and explosives location to the nearest point of the taxiway and to the centerline of the runway.

C. *Applying Ammunition and Explosives Safety Distances.* Separation distances between the following areas and from these areas to other targets, shall be determined by applying Tables 6-3.1 and 6-3.2:

1. Combat aircraft parking areas.

2. Ammunition and explosives cargo areas.

3. Ammunition and explosives storage facilities.

4. Ammunition and explosives operating facilities.

D. *Ammunition and explosives Prohibited Areas.* All ammunition and explosives shall be prohibited in any area under approach/departure zones of all

fixed and rotary wing aircraft landing facilities. The approach/departure zones for aircraft (surfaces or areas) are those areas so designated and described in detail for the various types of facilities in airfield and airspace criteria directives of the DoD Components. In general, the approach/departure zone begins near the end of a runway or landing area and extends outward to a given distance along, and symmetrically on each side of, the extended runway centerline or the aircraft approach axis of a heliport. Such zones flare uniformly from the landing area outward to a prescribed limit.

6–3. Quantity-Distance Tables

TABLE 6–3.1—*Quantity-Distance Standards for Mass-Detonating Ammunition and Explosives (Class 1, Division 1)*

Over	Not Over	Distance in feet for specific targets indicated in Table 6–3.2 [1]
Col. 1	Col. 2	Col. 3
0	50 [2]	110
50	100	140
100	200	175
200	300	200
300	400	220
400	500	240
500	600	255
600	700	265
700	800	280
800	900	290
900	1,000	300
1,000	1,500	345
1,500	2,000	380
2,000	3,000	435
3,000	4,000	480
4,000	5,000	515
5,000	6,000	545
6,000	7,000	575
7,000	8,000	600
8,000	9,000	625
9,000	10,000	645
10,000	15,000	740
15,000	20,000	815

TABLE 6–3.1—*Quanity-Distance Standards for Mass-Detonating Ammunition and Explosives (Class 1, Division 1)*

Over	Not Over	Distance in feet for specific targets indicated in Table 6–3.2 [1]
Col. 1	Col. 2	
20,000	25,000	875
25,000	30,000	935
30,000	35,000	980
35,000	40,000	1,025
40,000	45,000	1,070
45,000	50,000	1,105
50,000	55,000	1,140
55,000	60,000	1,175
60,000	65,000	1,205
65,000	70,000	1,235 [3]
70,000	75,000	1,265
75,000	80,000	1,295
80,000	85,000	1,320
85,000	90,000	1,345
90,000	95,000	1,370
95,000	100,000	1,300
100,000	125,000	1,500
125,000	150,000	1,595
150,000	175,000	1,675
175,000	200,000	1,755
200,000	225,000	1,825
225,000	250,000	1,890
250,000	275,000	1,950
275,000	300,000	2,005
300,000	325,000	2,065
325,000	350,000	2,115
350,000	375,000	2,165
375,000	400,000	2,210
400,000	425,000	2,250
425,000	450,000	2,300
450,000	475,000	2,340
475,000	500,000	2,380

NOTES:

[1] To protect against low-angle, high-speed fragments, barricades should be provided; however, these distances shall not be reduced.

[2] The distance given for 0 to 50 pounds NEW constitutes the minimum spacing permitted.

[3] The minimum distance for Class 1, Division 1 of 1250 feet (Reference §5-2F) does not apply to targets for which this table is used.

Table 6-3.2 - Application of Ammunition and Explosives Safety Distances

FROM	TO: Combat Aircraft Parking Area	Ammunition/Explosives Cargo Area	Ammunition/Explosives Storage Facility	Ammunition/Explosives Operating Facility	Ready Ammunition Storage Facility	Inhabited Building	Public Traffic Route	Runway/Taxiway (Joint DoD-Non DoD Use)	Runway/Taxiway (DoD Component Use Only)	Aircraft Parking Area	Aircraft Passenger Loading/Unloading Area	Recreation Area
Combat Aircraft Parking Area	3a	3a	3	4	3	1	2	2	None	10	7	8
Ammunition/Explosives Cargo Area	3a	3a	3	4	3	1	2	2	None	10	7	9
Ammunition/Explosives Storage Facility	5	3	3	4	3	1	2	2	11	6	7	9
Ammunition/Explosives Operating Facility	5	3	3	4	3	1	2	2	11	6	7	9
Ready Ammunition Storage Facilities	3a	3a	3	4	3	1	2	2	None	10	7	8

NOTE:

a. Protects against simultaneous detonation of ammunition on adjacent aircraft, but does not prevent serious damage to aircraft and possible propagation of detonation due to fragments, debris, or fire.

KEY TO TABLE 6-3.2

1. Use appropriate inhabited building distance specified in Chapters 5 or 8.
2. Use appropriate public traffic route distance specified in Chapters 5 or 8.
3. Use appropriate intermagazine distance specified in Tables 5-3.5, 5-5.1, 5-5.2, 5-5.3, 5-5.4, 5-6.1 or 5-7.1.
4. Use appropriate intraline distance specified in Tables 5-3.3, 5-5.1, 5-5.2, 5-5.3, 5-5.4 or 5-6.1.
5. Use Table 6-3.1 distances for mass-detonating items and appropriate public traffic route distances specified in Chapter 5 for non-mass detonating items.
6. Use Table 6-3.1 distances for DoD Component aircraft parking areas, and appropriate inhabited building distance (chapter 5) for non-DoD Component aircraft parking areas.
7. Use appropriate public traffic route distances for locations in the open where passengers emplane and deplane; use appropriate inhabited building distance if a structure is included where passengers assemble, such as a passenger terminal building.
8. No distance required to recreational areas which are used exclusively for alert personnel manning the combat loaded aircraft. Other recreational areas where people are in the open shall be at appropriate public traffic route distance as specified in Chapters 5 and 8. When structures, including bleacher stands, are a part of such area, appropriate inhabited building distance, as specified in Chapters 5 and 8 shall be used.
9. Recreational areas, where people are in the open, shall be at appropriate public traffic route distance as specified in Chapters 5 and 8. When structures, including bleacher stands are part of such area, appropriate inhabited building distance, as specified in Chapters 5 and 8 shall be used.
10. Within these areas of airfields, heliports, and seadromes exclusively used by DoD Components, the separation of aircraft parking areas from combat aircraft parking areas and their ready ammunition storage facilities and ammunition/explosives cargo areas are considered to be a command function. At joint DoD/non-DoD use airfields, heliports, and seadromes, the combat aircraft parking areas and its ready ammunition storage facilities and ammunition and explosives cargo area will be separated from non-DoD aircraft as specified in 6 above.
11. Use column 4, Table 5-3.3 distances from side or rear of standard earth-covered magazine containing mass-detonating items to taxiway; use appropriate public traffic route distance (chapter 5 or 8) from side or rear of standard earth-covered magazine containing non-mass detonating items to taxiway; use appropriate public traffic route distance (chapter 5 or 8) from front of standard earch-covered magazines, and from any other storage location containing mass-detonating or non-mass detonating items to taxiway; and use appropriate public traffic route distance (chapters 5 or 8) from any storage location containing mass-detonating or non-mass detonating items to runway.

CHAPTER 7

EXPLOSIVES SAFETY STANDARDS FOR PIER AND WHARF FACILITIES

7-1. Scope

This chapter details the quantity-distance standards for pier and wharf facilities handling ammunition and explosives.

7-2. Application

A. These quantity-distance standards apply to the separation of piers and wharves and associated facilities at which ammunition and explosives may be handled, present in ships' holds or service conveyances, and to the location of this ammunition and explosives with respect to inhabited buildings, public traffic routes, and other adjacent auxiliary facilities.

B. These standards are not applicable to ammunition or explosives stored in ships' magazines and intended for the service of the shipboard armament or aircraft. They do, however, apply to the loading, off-loading, storage, or shifting of such ammunition or explosives.

C. When hazards associated with non mass-detonating ammunition and explosives (Classes 1, Divisions 2 through 4) are involved, the safety distances prescribed for such hazards shall be applied as appropriate.

7-3. Basic Objectives for Ship or Barge Separation

A. To separate ship or barge units by a sufficient distance to avert, or markedly reduce, the possibility of mass-detonation of adjacent ship or barge units when a detonation occurs in one, and thus provide separation from other targets on the basis of the greatest amount of mass-detonating explosives in any one ship or barge unit. This recognizes that ships or barges in adjacent units may detonate subsequently as a result of fires caused by the initial explosion or detonation. Separation of any two ships or barge units by the distances specified in Column 9 ($11W^{1/3}$), Table 5-3.4 is expected to provide at least as much protection against immediate communication as is provided for aboveground magazines. In such cases, coalescence of shock waves from the two explosions is unlikely and the quantities of explosives in the two need not be totalled for quantity-distance purposes.

B. To separate ship or barge units by a sufficient distance to avert, or markedly reduce, the possibility of communication of explosions regardless of time, such that damage to ships in adjacent units from blast and fragments will be limited to the superstructure and nonvital members, and the possibility of deaths and injuries will be reduced to a minimum. Reference Column 3, Table 7-7.1.

C. To separate explosive loaded ship or barge units by a sufficient distance to limit damage to ships in adjacent units, or unrelated non-explosive ships to that of a minor nature, and virtually eliminate deaths and serious injuries. Reference Column 4, Table 7-7.1.

D. To maintain the greatest separation compatible with existing operational requirements if the objectives of the preceding paragraphs cannot be met. Communication between explosive units without intervening protection is considered virtually certain at separation distances of 300 feet or less. At separations greater than this figure, the probability continuously decreases as the distance increases. This decrease is not a scalable quantity, however, so that a finite probability value cannot be assigned to different separation distances. For any given separation, however, the probability of communication should be less for ships moored in tandem than in parallel; and for those which have hatches closed and are not working as compared with those which have exposed ammunition on deck and in open holds. These and other favorable factors should be taken into account to reduce the amount of explosives involved in any potential incident.

7-4. Determination of Quantity of Explosives in a Ship

A. On board ship, the various types of ammunition and explosives are stored relatively close to each other, and a detonation in the high explosives part of the cargo may receive considerable support

from items that are normally considered to be only fragment or fire hazards; therefore, the total quantity of explosives on board a ship shall be determined as specified in paragraph 3-2.

B. When ship units are separated in accordance with Column 9, Table 5-3.4 distances or greater, the quantity of explosives to be used in entering the tables will be the greatest quantity in any of the ship units under consideration; if not so separated, the quantity to be used will be the total in all units.

7-5. Measurement of Separation Distance

A. *Ships at a Pier.* Measurement of separation distances between ships (Reference Chapter 2) will be from the nearest point of one unit to the nearest point of the other. Movement of cars passing through the clear space is considered as an operational risk. It will generally be found impracticable to separate berths at a single pier by sufficient distance to prevent mass detonation of ships containing complete cargoes of Class 1, Division 1 ammunition. To the extent operationally feasible, therefore, scheduling should be such as to reduce the number of such exposures and the total time that they are required.

B. *Piers.* The separation distances between piers will be measured from the nearest point of the ship unit at one pier to the nearest point of the ship unit under consideration at the other pier.

C. *Anchorages.* Measurements from anchorages will generally be from the boundary of the area designated for the scuttling site or the explosives anchorage. In the case of the explosives anchorage, the separation distance to outside targets will depend upon whether:

1. The ship units that are loading or unloading within the explosives anchorage are properly separated, taking into consideration location and the amount of explosives in each ship unit. The ship unit equivalent for an explosives anchorage is a circle, the radius of which is the distance from the mooring buoy or the ship's anchor, to the stern of the ship or of the ammunition lighters alongside, when riding to the full scope of the chain. To maintain proper separation distance between loading or unloading ship units in the explosives anchorage, the ships should moor or anchor so that at no time will they have a separation distance less than specified in Column 9, Table 5-3.4, if quantities are not to be totalled.

2. The ships being loaded or unloaded at one area are properly separated from the loaded ships in another area and whether the loaded ships within the loaded ship area are properly separated from each other. If the latter conditions do not apply, then the quantity for entering the table shall be the total quantity rather than the unit quantity.

D. *Dolphins or Interrupted Quays.* Measurement of separation distance between ships moored to dolphins or interrupted quays will be from the nearest point of one unit to the nearest point of the other. Reference Chapter 2.

E. *Fixed Targets.* The measurement of separation distance from moored ships to fixed targets on land will be from the nearest boundary of the ship or barge unit to the nearest fixed target.

7-6. Siting Criteria and Application of Quantity-Distance Separation Standards

A. *Scuttling Site.*

1. A properly located scuttling site should be provided, if practicable, for positioning a ship for its flooding or sinking in the event a vessel catches fire and must be moved to avert damage to other ships or piers. It should have sufficient sea room and depth of water to permit the sinking of the largest vessel which may be handled at the installation so that the holds will be completely flooded at low water.

2. Since an explosion may occur while the vessel is being moved, the location of the scuttling site should provide the best available protection to other ships, piers, and shore installations.

3. The location of the scuttling site will depend on the greatest net quantity of mass-detonating explosives which may be in a single ship at any one time. The quantity-distance tables to be used will depend on the particular types of targets.

4. The following tables are applicable for determining distance separation to be maintained from scuttling site:

a. Non-Explosive Piers. Column 4, Table 7-7.1.

b. Explosives Anchorage. Column 3, Table 7-7.1.

c. Inhabited Buildings. Column 3, Table 5-3.1.

d. Public Traffic Routes Including Ship Channels. Column 4, Table 5-3.1.

B. *Explosives Anchorage.* The location of an explosives anchorage should not only be separated from the main ship channel or from normally traversed routes of ships entering or leaving the harbor by Column 4, Table 5-3.1 but also by the turning

circles and stopping distances of the ships. Assuming that the diameter of the turning circle of a ship is 1,000 yards, an explosives anchorage should be so located that a ship in the channel with a jammed rudder would clear an anchored explosives-laden ship. From the turning circle standpoint, the separation distance should not be less than 3,000 feet.

1. Tables applicable to explosives anchorages are as follows:

a. Separation of Ships at Explosives Anchorages.

(1) When explosives anchorages are used for loading and unloading ships, as well as for fully loaded vessels anchored at their berths, ships that are being loaded or unloaded shall be separated from fully loaded ships in accordance with Column 4, Table 7-7.1 distances.

(2) When the explosives anchorage is used only for loading and unloading ships, in order to prevent mass-detonation, ships in the explosives anchorage shall be separated by the distances specified in Column 9, Table 5-3.4. Greater protection, however, is afforded by Column 3, Table 7-7.1 and should be used wherever possible to reduce loss of shipping from any single incident.

(3) Separation of loaded ships one from the other shall be in accordance with Column 3, Table 7-7.1. Reference paragraph 7-3B.

b. Separation of Explosives Anchorages from Other Targets.

(1) Explosives anchorages shall be separated from explosives piers by distances of Column 4, Table 7-7.1. Reference paragraph 7-3C3. If the explosives anchorage is to be used only for the loading and unloading of vessels, Column 3, Table 7-7.1 applies.

(2) Table 5-3.1 applies for the separation distance between the explosives anchorage and inhabited buildings or public traffic routes.

C. *Separation Distances of Ship Units in Tandem at the Same Pier.*

1. Since the second ship would be in an area of heavy fragment density from the exploding ship, it could be set on fire and later caused to mass-detonate. A direct hit by a steel fragment on ammunition alongside the ship or in an open hold could also cause a mass-detonation. The separation distances based on blast damage alone are accordingly not sufficient to take care of such fragment hazards. Berthing of the two ships in tandem will help to decrease the fragment hazard to the explosives cargo of the second ship because of the additional protection afforded by the bow or stern.

2. When two ships cannot be separated by the distances specified in Column 9, Table 5-3.4 and are being loaded through all hatches, the spotting of cars and the loading of hatches in both ships should be planned so as to put the greatest possible distance between open hatches of both ships, and between the trucks and freight cars serving the two ships. When possible, the loading of ships should be staggered.

D. *Separation Distance for Piers.* The distances for separation of piers, Column 3, Table 7-7.1, are based on the premise that if a ship with a full load of mass-detonating ammunition and explosives exploded as a unit at one pier, the possibilities of communication of the explosion to another ammunition ship at the second pier would be remote. Damage to the other ship would be superficial. By "superficial" is meant some damage to decks and superstructure from being struck by fragments and debris and the buckling of some doors and bulkheads on weather decks by blast. Disarrangement of and damage to exposed vulnerable equipment such as radio and radar gear can be expected. There is a possibility of occasional injury or death to exposed personnel from being struck by fragments of the exploding ship or from secondary effects of blast (being thrown overboard or off insecure footing, or being struck by loose objects).

E. *Separation of Explosives Ships From Other Ships.*

1. The distances for separation of explosives ships from other ships (Column 4, Table 7-7.1) are such that if one ship with mass-detonating explosives exploded as a unit, the ship or ships separated from it by these distances would suffer only very minor superficial damage from the blast wave with the probability of only a few fragments hitting the ship. Fatalities or serious injuries would be rare.

2. Distances of Column 4, Table 7-7.1 shall be used for the protection of loaded ammunition ships, non explosive-carrying ships, and laid up ships. After an ammunition ship has been loaded, it shall not be subjected to the hazards of a possible explosion from an ammunition ship that is still loading. The same applies to nonmilitary and passenger ships. For protection of ships which are underway, however, Column 4, Table 5-3.1, shall be used.

7-7. Quantity-Distance Tables

A. Separation Distance Between Ships and Piers—(Reference figure 7-7.1)

TABLE 7-7.1

Separation Distance Between Ships & Piers

Million Pounds NEW		Distance in Feet	
Over	Not Over	Separation of Piers $D = 18W^{1/3}$	Separation of Explosive Ships from Other Ships $D = 40W^{1/3}$
Col. 1	Col. 2	Col. 3	Col. 4
0	.001 [1]	180	400
.001	.25	1,135	2,520
.25	.50	1,430	3,175
.50	.60	1,520	3,375
.60	.70	1,600	3,550
.70	.80	1,670	3,715
.80	.90	1,740	3,860
.90	1.00	1,800	4,000
1.00	1.25	1,940	4,310
1.25	1.50	2,060	4,580
1.50	1.75	2,170	4,820
1.75	2.00	2,270	5,040
2.00	2.25	2,360	5,240
2.25	2.50	2,445	5,430
2.50	2.75	2,520	5,605
2.75	3.00	2,595	5,770
3.00	3.25	2,665	5,925
3.25	3.50	3,735	6,075
3.50	3.75	2,795	6,215
3.75	4.00	2,855	6,350
4.00	4.25	2,915	6,480
4.25	4.50	2,970	6,605

TABLE 7-7.1

Separation Distance Between Ships & Piers

Million Pounds NEW		Distance in Feet	
Over	Not Over	Separation of Piers $D = 18W^{1/3}$	Separation of Explosive Ships from Other Ships $D = 40W^{1/3}$
Col. 1	Col. 2	Col. 3	Col. 4
4.50	4.75	3,025	6,725
4.75	5.00	3,080	6,840
5.0	5.5	3,175	7,060
5.5	6.0	3,270	7,270
6.0	6.5	3,360	7,465
6.5	7.0	3,445	7,650
7.0	7.5	3,525	7,830
7.5	8.0	3,600	8,000
8.0	8.5	3,675	8,165
8.5	9.0	3,745	8,320
9.0	9.5	3,815	8,470
9.5	10.0	3,880	8,620
10.0	11.0	4,005	8,895
11.0	12.0	4,120	9,160
12.0	13.0	4,230	9,405
13.0	14.0	4,430	9,640
14.0	15.0	4,440	9,865

NOTE:

[1] The distance given for 0 to 1,000 pounds NEW constitutes the minimum spacing permitted.

7-8. Minimum Quantity-Distance Separation Between Ship or Barge Units and Other Areas

TABLE 7-8.1—*Ship or Barge Units*

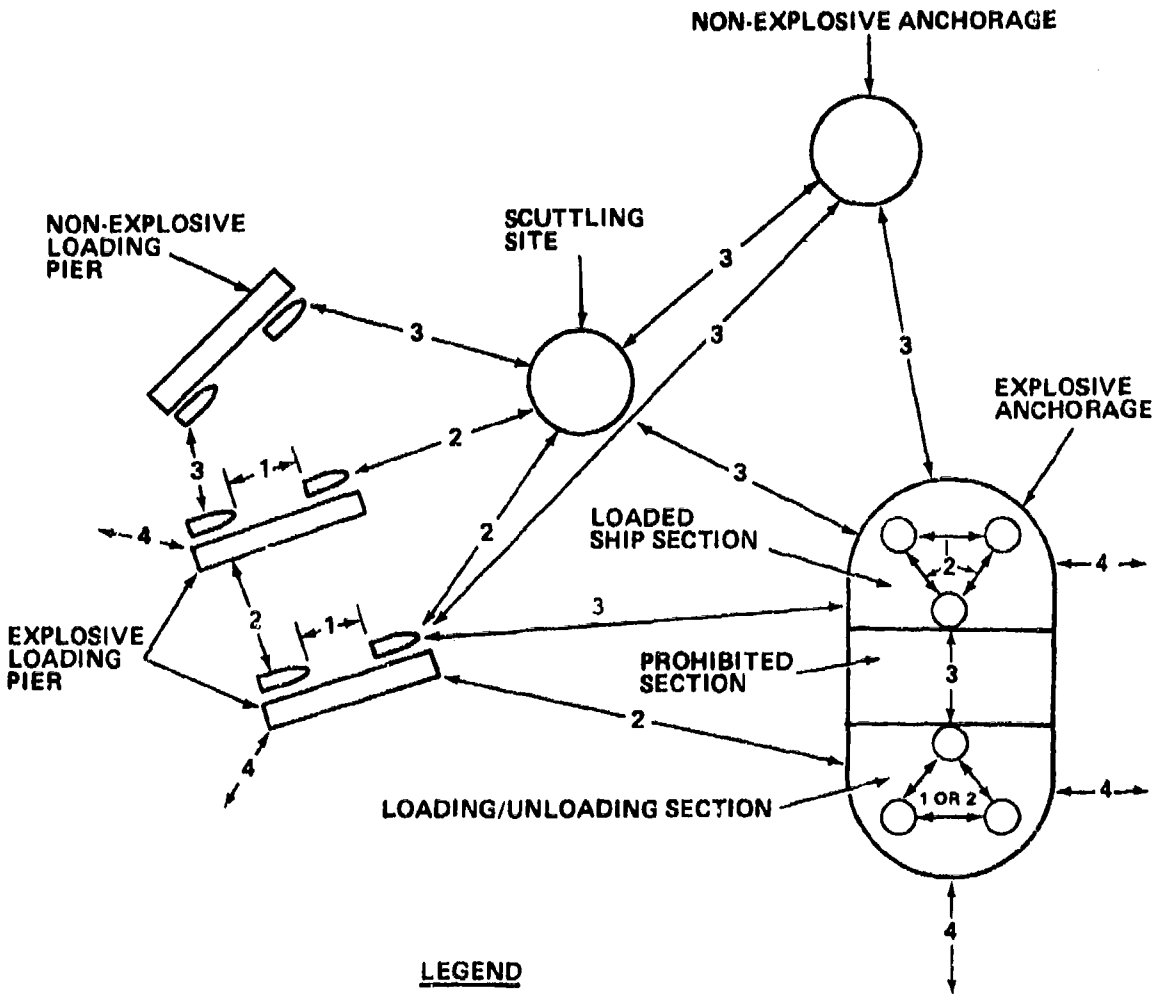
Item No.	To determine separation between ship or barge units and following targets	Toward Target Use[1]		From Target Use[2]		Remarks
		Table	Col.	Table	Col.	
1	Terminal boundary	5-3.1	3	N/A		
2	Main ship channel	5-3.1	4	N/A		
3	Public traffic route	5-3.1	4	N/A		
4	Administration and industrial areas	5-3.1	3	N/A		
5	Inert storage area			N/A		Ref. para. 3-5F
6	Recreation area	5-3.1	4	N/A		Ref. para. 3-5I
7	Steel tanks on surface	7-7.1	4	N/A		Ref. para. 3-5G
8	Explosives Anchorage:					
	a. Loaded ship area	7-7.1	4	7-7.1	4	Larger Distance Governs
	b. Loading and unloading area	7-7.1	4	7-7.1	4	Do.
	c. Ship or barge unit (both in same anchorage)	7-7.1	3	7-7.1	3	Do.
	d. Ship or barge unit (in different anchorages)	7-7.1	4	7-7.1	4	Do.
9	Classification yard	5-3.4	8-9	Ref. paras. 3-2, B.2.b, and 3-5C.		
10	Explosives operating area	5-3.1	3	5-3.1	3	Larger Distance Governs
11	Ammunition and Explosives Storage	5-3.4	8-9	5-3.1	3	Do.
12	Holding yard	5-3.4	8-9	5-3.1	3	Do.
13	Scuttling Site	N/A		7-7.	3 or 4	

NOTES:

[1] Use quantity of explosives in ship or barge units.

[2] Use quantity of explosives at target.

B– APPLICATION OF SEPARATION DISTANCE OF TABLES 5–3.1, 5–3.4 AND 7–7.1 FOR SHIP AND BARGE UNITS



LEGEND

1	COLUMN 9 TABLE 5–3.4 REF. PARAS. 7–3, 7–5A AND 7–6C
2	COLUMN 3, TABLE 7-7.1
3	COLUMN 4, TABLE 7-7.1
4	COLUMNS 3 & 4, TABLE 5-3.1
	SHIP AND BARGE UNITS

FIGURE 7–7.1 – APPLICATION OF SEPARATION DISTANCE OF TABLE 5–3.1 5–3.4 AND 7–7.1 FOR SHIP AND BARGE UNITS.

CHAPTER 8

QUANTITY-DISTANCE STANDARDS FOR LIQUID PROPELLANTS

8-1. Scope

A. The provisions of this chapter apply to all types of liquid propellant storage areas, including missiles, rockets, and multicompartment tanks in which both liquid fuels and oxidizers are stored. It covers:

1. quantity limitations and distance standards;
2. storage compatibility groupings;
3. explosive equivalencies for liquid propellant mixtures; and
4. hazards of the propellants when in the gaseous as well as the liquid state.

B. This chapter does not apply to—

1. Toxic hazards or distances for protection therefrom; in some cases, the toxic hazard may be the controlling factor in siting and storage of liquid propellants. Pertinent regulations concerning toxic hazards will be applied in conjunction with these standards.

2. A single standard minimum-size shipping container such as one 55-gallon drum, one 500-pound (net weight) cylinder, etc., of the particular propellant involved, nor to lesser quantities; these will be stored and handled as prescribed by the controlling DoD Component.

8-2. Concept

A. The DoD Component sponsoring the development of a liquid propellant, or first adopting for use any liquid propellant not listed in this chapter, shall be responsible for assigning the proper hazard classification and compatibility grouping, and for coordinating such assignment with other DoD Components.

B. These quantity-distance standards were developed on the premise that the controlling DoD Component shall assure that the materials of construction are compatible with the propellants, facilities are of appropriate design, fire protection and drainage control techniques are employed, and other specialized controls (e.g., nitrogen padding or blanketing, tank cooling, etc.) are used when required.

C. When additional hazards associated with ammunition or explosives are involved, the safety distances prescribed in Chapter 5 will be applied as appropriate.

D. Quantity-distance standards for other conditions and explosive equivalents for any combination not contained in Table 8-11.1 are to be determined by the controlling DoD Component.

E. These standards are based upon the estimated credible damage resulting from an incident, without considering probabilities of frequency of occurrence.

8-3. Determination of Propellant Quantity

A. The total quantity of propellant in a tank, drum, cylinder, or other container shall be the net weight of the propellant contained therein. Where the storage containers are not separated one from the other by the appropriate distance or are not so subdivided as to prevent possible accumulative involvement, the quantity shall be considered as the total of all such storage containers. Quantity of propellant in the associated piping must be included to the point(s) where positive means are provided for interrupting the flow through the pipe, or interrupting a reaction in the pipe in the event of an incident.

B. Where incompatible propellants (reference paragraph 8-9) are not separated by the required distances or provisions are not made to prevent their mixing, the combined quantity of the two will be used. Consult Table 8-11.1 to determine if explosive equivalents apply.

C. When propellants (compatible or incompatible) at a specific location are subdivided so that the possibility of accumulative involvement is positively limited to the quantity of propellant in any one of the divided segments, quantity-distance separation does not apply between such segments. However, the propellant content of the segment requiring the greatest distance shall be used to determine the separation to be maintained between the

propellant location and other targets.

D. When the quantities of propellants are given in gallons, the conversion factors given in Table 8-12.1 may be used to determine the quantity in pounds.

8-4. Measurement of Separation Distances

A. Separation distances shall be measured from the closest hazard source (containers, buildings, segment, or positive cutoff point in piping, whichever is controlling).

B. Where buildings containing a small number of cylinders or drums are present or where quantities of propellant are effectively subdivided, distances may be measured from the nearest container or controlling subdivision.

8-5. Incompatible Storage

Separation distances between propellants of different compatibility groups will be the inhabited building distance for the propellant quantity and the group which requires the greater distance. Consult Table 8-11.1 to determine if explosive equivalents apply and, if so, use distances found in Table 5-3.1 or 5-3.3.

8-6. Compatible Storage

Compatible storages of different propellants will be separated by the intragroup storage distances required by the more hazardous groups.

8-7. Hazard Groupings

Liquid propellants present various types and degrees of hazards. Based on these hazards, the following propellent groupings are established:

A. Group I comprises those assigned materials which are considered to be the least hazardous. They have a fire-hazard potential and require separation distances specified in paragraph 8-10A.

B. Group II comprises those assigned materials which are strong oxidizers. They exhibit properties such as vigorous oxidation of, or rapid combustion in contact with, materials such as organic matter. Such contact may result in serious fires. These hazards necessitate use of the prescribed minimum spacing of storages and quantity limitations to restrict the loss of valuable property (Reference paragraph 8-10B).

C. Group III presents hazards primarily from the pressure rupture of the storage container resulting from fire, deflagration, or vapor phase explosions. Either pressure rupture of the container or vapor phase explosion can cause a fragment hazard from the container and its protective structure, or other adjacent material. Separation distances for this hazard group are specified in paragraph 8-10C.

D. Group IV presents hazards which are the same as those of mass-detonating explosives. Incidents may create both blast overpressures and severe fragment hazards from the containers and surrounding equipment and material (Reference paragraph 8-10D).

8-8. Specific Hazardous Locations

Aside from the fact that the propellants differ from each other, as explained for the above groups, the predominant hazard of the individual propellant can vary depending upon the location of the propellant storage and the operation(s) involved. In order of decreasing hazard, these conditions are:

A. *Range Launch Pads.*

These involve research, development, testing, and space exploration launchings. Operations at these facilities are very hazardous because of the proximity of fuel and oxidizer to each other, the frequency of launchings, lack of restraint of the vehicle after liftoff, and the possibility of fallback with resultant dynamic mixing on impact. Launch vehicle tankage is involved here and explosive equivalents must be used.

B. *Operational Launch Pads.*

Activity here is similar to that at range launch pads except the frequency of firing is much less at the operational launch pads; the latter are defense or combat-type operations and can well be one time events. Launch vehicle tankage is involved and explosive equivalents must be used except as provided in paragraph 8-5. When an operational pad is used for training launches, it shall be considered as a range launch pad.

C. *Static Test Stands.*

Although these can involve experimental operations, the units remain static and are subject to better control than launch vehicles. Except where run tankage for fuel and oxidizer are mounted one above the other, it is possible to separate the tankage to reduce the hazard over that for the rocket or missile on the launch pad. Explosive equivalents must be used except as provided in paragraph 8-5.

D. *Ready Storage.*

This storage is relatively close to the launch and static test stands; normally it is not directly involved in feeding the engine as in the case with run tankage which is an integral part of all launch and test stand operations. The explosive equivalents

must be used if the facility design does not guarantee against fuel and oxidizer mixing and against detonation propagation to, or initiation at, the ready storage facility when a mishap occurs at the test stand, on the ground at the launch pad, or at the ready storage areas. Otherwise, fire and fragment hazards will govern.

E. *Cold-Flow Test Operations.*

Fire and fragment hazards govern if the design is such that the system is closed except for approved venting, is completely airtight, fuel and oxidizer are never employed concurrently, and each has a completely separate isolated system and fitting types to preclude intermixing, and the propellants are of required purity. Otherwise, explosive equivalents must be used.

F. *Bulk Storage.*

This is the most remote storage with respect to launch and test operations. It consists of the area, tanks, and other containers therein, used to hold propellant for supplying ready storage and, indirectly, run tankage where no ready storage is available. Fire and fragment hazards govern. If positive measures are not taken to prevent mixing of fuel and oxidizer or to prevent detonation propagation, the explosive equivalents must be used.

G. *Rest Storage.*

This is temporary type storage and most closely resembles bulk storage. It is a temporary parking location for barges, trailers, tank cars, and portable hold tanks used for topping operations when these units are not actually engaged in the operation; and for such vehicles when they are unable to empty their cargo promptly into the intended storage container. Fire and fragment hazards govern. The transporter becomes a part of that storage to which it is connected during propellant transfer.

H. *Run Tankage (Operating Tankage).*

This consists of the tank and other containers and associated piping used to hold the propellants for direct feeding into the engine or device during operation. The contents of properly separated "run tanks" (operating tankage) and piping are normally considered on the basis of the pertinent hazards for the materials involved, except for quantities of incompatible materials that are or can be in a position to become mixed. High explosive equivalents will be used for quantities of such materials subject to mixing.

I. *Pipelines.*

A 25-foot clear zone to inhabited buildings shall be maintained on each side of pipelines used for Group II or III propellants.

8-9. Liquid Propellant Hazard and Compatibility Groupings

TABLE 8-9.1—*Hazard and Compatibility Groups*

Propellant	Hazard Group [1]	Compatibility Storage Group [2]
The alcohols CH_3OH, C_2H_5OH, $(CH_3)_2CHOH$	I	C
Anhydrous ammonia NH_3	I	C
Aniline $C_6H_5NH_2$	I	C
Hydrocarbon fuels JP-4, JP-5, RP-1	I	C
Monopropellant NOS-58-6	I	G
Nitrogen tetroxide N_2O_4	I	A
Otto fuel II	I	G
Red fuming nitric acid HNO_3	I	A
Bromine pentafluoride BrF_5	II	A
Chlorine triflouride ClF_3	II	A
Hydrogen peroxide (H_2O_2) greater than 52%	II [3]	A
Liquid flourine LF_2	II	A
Liquid oxygen LO_2	II	A
Perchloryl flouride ClO_3F	II	A
Oxygen diflouride OF_2	II	A
Ozone diflouride O_3F_2	II	A
Ethylene oxide C_2H_4O	III	D
Hydrazine N_2H_4	III	C
Hydrazine-UDMH mixtures	III	C
Liquid hydrogen LH_2	III	C
Mixed amine fuels	III	C
Monomethylhydrazine CH_3NHNH_2	III	C
Pentaborane B_5H_9	III	D
Triethyl Boron B $(C_2H_5)_3$	III	D
UDMH $(CH_3)_2NNH_2$	III	C
Nitromethane CH_3NO_2	IV [4]	F [5]
Tetranitromethane $C(NO_2)_4$	IV	F

NOTES

[1] For some of the materials listed, the toxic hazard may be an overriding consideration. Consult applicable regulations and, if necessary, other authorities or publications for determination of toxic siting criteria.

[2] Propellants with the same compatibility group letter are considered as compatible propellants and unlike letters incompatible. It is to be noted that these compatibility groups are not to be confused with those given in Chapter 4.

[3] Under certain conditions concentrated hydrogen peroxide greater than 90% will detonate. However, its sensitivity to detonation is no greater than that of a standard energetic double base solid propellant under the same conditions.

[4] Technical grade or better nitromethane in unit quantities of 55 gallons or less in DOT 17E or C drums may be stored using Group II distances provided that:

a. Drums are stored only one tier high.

b. Drums are protected from direct rays of the sun.

c. Maximum storage life of two years is enforced unless storage life tests indicate product meets purchase specifications at that time. Such tests are to be repeated at one year intervals thereafter.

[5] Nitromethane is chemically compatible with Compatibility Storage Group C liquid propellants; however, due to difference in hazards, nitromethane should be stored separately.

8-10. Quantity-Distance Standards

The following standards are applicable to liquid propellants used for propulsion or operation of missiles, rockets, and other related devices:

A. *Group I. Table 8-10.1 applies.* When Group I materials are stored with more hazardous materials under conditions prescribed in paragraph 8-8

Tables 8-11.1, *5-3.1*, and *5-3.3* apply, as appropriate.

B. *Group II. Table 8-10.2 applies.* When Group II materials are stored with more hazardous materials under conditions prescribed in paragraphs 8-8, Tables 8-11.1, *5-3.1*, and *5-3.3* apply, as appropriate.

C. *Group III. Table 8-10.3 applies.* When Group III materials are stored with more hazardous materials under conditions prescribed in paragraph 8-8, Tables 8-11.1, *5-3.1*, and *5-3.3* apply, as appropriate.

D. *Group IV. Tables 5-3.1, 5-3.3 and 8-11.1 apply.* Enter weight of explosive equivalent in columns 1 and 2, Tables *5-3.1* or *5-3.3*; appropriate distances can then be determined for the applicable circumstances.

Example:

8,000 lbs LO_2/LH_2 at 60 percent	=	4,800
100,000 lbs LO_2/RP-1 at 10 percent	=	10,000
Total		14,800

14,800 lbs or (15,000 lbs) = 900 ft inhabited building distance.

TABLE 8-10.1—*Hazard Group I*

Pounds of Propellant		Inhabited Buildings, Public Traffic Routes, and Incompatible Group I Storage (feet)	Intragroup[1] and Compatible Group I Storage (feet)
Over	Not Over		
Col. 1	Col. 2	Col. 3[4]	Col. 4[5]
0	100[3]	30	25
100	200[3]	35	30
200	300[3]	40	35
300	400[3]	45	35
400	500[3]	50	40
500	600	50	40
600	700	55	40
700	800	55	45
800	900	60	45
900	1,000	60	45
1,000	2,000	65	50
2,000	3,000	70	55
3,000	4,000	75	55
4,000	5,000	80	60
5,000	6,000	80	60
6,000	7,000	85	65
7,000	8,000	85	65
8,000	9,000	90	70
9,000	10,000	90	70
10,000	15,000	95	75
15,000	20,000	100	80
20,000	25,000	105	80
25,000	30,000	110	85
30,000	35,000	110	85
35,000	40,000	115	85
40,000	45,000	120	90
45,000	50,000	120	90
50,000	60,000	125	95
60,000	70,000	130	95
70,000	80,000	130	100
80,000	90,000	135	100
90,000	100,000	135	105
100,000	125,000	140	110
125,000	150,000	145	110
150,000	175,000	150	115
175,000	200,000	155	115
200,000	250,000	160	120
250,000	300,000	165	125
300,000	350,000	170	130
350,000	400,000	175	130
400,000	450,000	180	135
450,000	500,000	180	135
500,000	600,000	185	140
600,000	700,000	190	145
700,000	800,000	195	150
800,000	900,000	200	150
900,000	1,000,000[2]	205	155
1,000,000	2,000,000	235	175
2,000,000	3,000,000	255	190
3,000,000	4,000,000	265	200
4,000,000	5,000,000	275	210
5,000,000	6,000,000	285	215
6,000,000	7,000,000	295	220
7,000,000	8,000,000	300	225
8,000,000	9,000,000	305	230
9,000,000	10,000,000	310	235

NOTES:

[1] Reference paragraphs 8-5 and 8-6.

[2] Reference paragraph 8-182.

[3] Extrapolations above 1,000,000 lb extend well outside data included in the Bureau of Mines Report from which original quantity-distance tables were derived, however, they are supported by independent calculations and knowledge of like phenomena.

[4] Values in Column 3 are one-half the group II inhabited building distance.

[5] Values in Column 4 are three-fourths the group II and group III intragroup distances.

TABLE 8-10.2—*Hazard Group II*

Pounds of Propellant		Inhabited Buildings, Public Traffic Routes, and Incompatible Group II Storage (feet)	Intragroup[1] and Compatible Group I Storage (feet)
Over	Not Over		
Col. 1	Col. 2	Col. 3	Col. 4
0	100[2]	60	30
100	200[2]	75	35
200	300[2]	85	40
300	400[2]	90	45
400	500[2]	100	50
500	600	100	50
600	700	105	55
700	800	110	55
800	900	115	60
900	1,000	120	60
1,000	2,000	130	65

TABLE 8-10.2—*Hazard Group II*—Continued

Pounds of Propellant		Inhabited Buildings, Public Traffic Routes, And Incompatible Group II Storage (feet)	Intergroup[1] and Compatible Group II Storage (feet)
Over	Not Over		
Col. 1	Col. 2	Col. 3[2]	Col. 4[3]
2,000	3,000	145	70
3,000	4,000	150	75
4,000	5,000	160	80
5,000	6,000	165	80
6,000	7,000	170	85
7,000	8,000	175	85
8,000	9,000	175	90
9,000	10,000	180	90
10,000	15,000	195	95
15,000	20,000	205	100
20,000	25,000	215	105
25,000	30,000	220	110
30,000	35,000	225	110
35,000	40,000	230	115
40,000	45,000	235	120
45,000	50,000	240	120
50,000	60,000	250	125
60,000	70,000	255	130
70,000	80,000	260	130
80,000	90,000	265	135
90,000	100,000	270	135
100,000	125,000	285	140
125,000	150,000	295	145
150,000	175,000	305	150
175,000	200,000	310	155
200,000	250,000	320	160
250,000	300,000	330	165
300,000	350,000	340	170
350,000	400,000	350	175
400,000	450,000	355	180
450,000	500,000	360	180
500,000	600,000	375	185
600,000	700,000	385	190
700,000	800,000	395	195
800,000	900,000	405	200
900,000	1,000,000[4]	410	205
1,000,000	2,000,000	470	235
2,000,000	3,000,000	505	255
3,000,000	4,000,000	535	265
4,000,000	5,000,000	555	275
5,000,000	6,000,000	570	285
6,000,000	7,000,000	585	295
7,000,000	8,000,000	600	300
8,000,000	9,000,000	610	305
9,000,000	10,000,000	620	310

NOTES:

[1] Reference paragraphs 8-5 and 8-6

[2] Reference paragraph 8-1B2

[3] Extrapolations above 1,000,000 lbs. extend well outside data included in the Bureau of Mines Report from which original quantity-distance tables were derived; however, they are supported by independent calculations and knowledge of like phenomena.

[4] Distances of Col. 3 were selected as three-fourths the Group III inhabited building distance and considered reasonable due to the lesser hazard

[5] Distances of Col. 4 were derived from the Bureau of Mines, Department of the Interior Report No. 5707, dated 1961, modified and extrapolated. They average 37.5 percent of the inhabited building distances given in this report.

TABLE 8-10.3—*Hazard Group III*

Pounds of Propellant		Inhabited Buildings, Public Traffic Routes, and Incompatible Group III Storage (feet)		Intergroup[1] and Compatible Group III Storage (feet)
Over	Not Over	Unprotected	Protected[2]	
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5
0	100[3]	600	80	30
100	200[3]	600	100	35
200	300[3]	600	110	40
300	400[3]	600	120	45
400	500[3]	600	130	50
500	600	600	135	50
600	700	600	140	55
700	800	600	145	55
800	900	600	150	60
900	1,000	600	150	60
1,000	2,000	600	175	65
2,000	3,000	600	190	70
3,000	4,000	600	200	75
4,000	5,000	600	210	80
5,000	6,000	600	220	80
6,000	7,000	600	225	85
7,000	8,000	600	230	85
8,000	9,000	600	235	90
9,000	10,000	600	240	90
10,000	15,000	1,200	260	95
15,000	20,000	1,200	275	100
20,000	25,000	1,200	285	105
25,000	30,000	1,200	295	110
30,000	35,000	1,200	300	110
35,000	40,000	1,200	310	115
40,000	45,000	1,200	315	120
45,000	50,000	1,200	320	120
50,000	60,000	1,200	330	125
60,000	70,000	1,200	340	130
70,000	80,000	1,200	350	130
80,000	90,000	1,200	360	135
90,000	100,000	1,200	365	135
100,000	125,000	1,800	380	140
125,000	150,000	1,800	395	145
150,000	175,000	1,800	405	150
175,000	200,000	1,800	415	155
200,000	250,000	1,800	425	160
250,000	300,000	1,800	440	165
300,000	350,000	1,800	455	170
350,000	400,000	1,800	465	175
400,000	450,000	1,800	475	180
450,000	500,000	1,800	485	180
500,000	600,000	1,800	500	185
600,000	700,000	1,800	515	190
700,000	800,000	1,800	530	195
800,000	900,000	1,800	540	200
900,000	1,000,000[4]	1,800	550	205
1,000,000	2,000,000	1,800	630	235
2,000,000	3,000,000	1,800	675	255
3,000,000	4,000,000	1,800	710	265
4,000,000	5,000,000	1,800	740	275
5,000,000	6,000,000	1,800	760	285
6,000,000	7,000,000	1,800	780	295
7,000,000	8,000,000	1,800	800	300
8,000,000	9,000,000	1,800	815	305
9,000,000	10,000,000	1,800	830	310

NOTES:
[1] Reference paragraph 8-5 & 8-6
[2] Reference paragraph 8-1B2.
[3] Extrapolations above 1,000,000 lbs. extend well outside data included in the Bureau of Mines Report from which original quantity-distance tables were derived; however, they are supported by independent calculations and knowledge of like phenomena.
[4] The term "protected" means that protection from fragments is provided by terrain, effective barricades, nets, or other physical means.
[5] Col. 3 distances are necessary to provide reasonable protection from fragments of tanks or equipment which are expected to be thrown in event of a vapor phase explosion.
[6] Distances of Col. 4 are the recommended inhabited building distances given in the Bureau of Mines, Department of the Interior Report No. 5707, dated 1961, and extrapolation thereof (2 cal/cm² on 1 percent water vapor curve).
[7] Col. 5 distances are an average of 37.5 percent of Col. 4.

8-11. Liquid Propellant Explosive Equivalents

TABLE 8-11.1—*Liquid Propellant Explosive Equivalents* [2, 3, 4, 5, 6, 7]

Propellant Combinations	Static Test Stands	Range Launch Pads
LO_2/LH_2 or B_2H_6 + an oxidizer	60%	60%
LO_2/LH_2 + LO_2/RP-1	Sum of 60% for LO_2/LH_2 10% for LO_2/RP-1	Sum of 60% for LO_2/LH_2 20% for LO_2/RP-1
LO_2/RP-1, LO_2/NH_3 or B_2H_6 + a fuel	10%	20% up to 500,000 lbs + 10% over 500,000 lbs
IRFNA/Aniline [1]	10%	10%
IRFNA/UDMH [1]	10%	10%
IRFNA/UDMH + JP-4 [1]	10%	10%
N_2O_4/UDMH + N_2H_4 [1]	5%	10%
N_2O_4/UDMH + N_2H_4 [1] + Solid propellants	5% + the explosive equivalent of the solid propellant	10% + the explosive equivalent of the solid propellant.
Tetranitromethane (alone or in combinations)	100%	100%
Nitromethane (alone or in combination)	100%	100%

NOTES:
[1] These propellant combinations are hypergolic
[2] The percentage factors given in the table are to be used to determine the equivalencies of propellant mixtures at static test stands and range launch pads when such propellants are located aboveground and are unconfined except for their tankage Other configurations shall be considered on an individual basis to determine the equivalencies
[3] The explosive equivalent weight calculated by the use of this table shall be added to any non-nuclear explosives weight aboard before distances can be determined from Table 5-3.1 and 5-3.3.
[4] These equivalencies apply also when the following substitutions are made:
a. Alcohols or other hydrocarbons may be substituted for RP-1.
b. BeF_2, ClF_3, F_2, H_2, H_2O_2, OF_2, or O_2F_2 may be substituted for LO_2.
c. MMH may be substituted for N_2H_4 or UDMH.
d. C_2H_4O may be substituted for any propellant.
e. NH_3 may be substituted for any fuel if a hypergolic combination results.
[5] Use LO_2/RP-1 distances for pentaborane plus a fuel and LO_2/LH_2 distances for pentaborane plus an oxidizer.
[6] For quantities of propellant up to but not over the equivalent of 100 lbs. of explosives, the distance shall be determined on an individual basis by the controlling DoD Component All personnel and facilities, whether involved in the operation or not, shall be adequately protected by proper operating procedures, equipment design, shielding, barricading, or other suitable means.
[7] Distances less than [illegible] are not specified. Where a number of prepackaged liquid propellant units are stored together, separation distance to other storage facilities shall be determined on an individual basis, taking into consideration normal hazard classification procedures.

8-12. Conversion Table

TABLE 8-12.1—*Factors To Be Used When Converting Gallons of Propellant Into Pounds* [1]

Item	Pounds per gallon	At temperature °F
Anhydrous ammonia	5.1	68
Aniline	8.5	68
Bromine pentafluoride	20.7	68
Chlorine trifluoride	15.3	68
Ethyl alcohol	6.6	68
Ethylene oxide	7.3	68
Fluorine	12.6	-306
Furfuryl alcohol	9.4	68
Hydrogen peroxide (90 percent)	11.6	66
Hydrazine	8.4	68
Isopropyl alcohol	6.6	68
Liquid hydrogen	.59	-423
Liquid oxygen	9.5	-297
Methyl alcohol	6.6	68
Monomethyl hydrazine	7.3	68
Nitromethane	9.5	68
Nitrogen tetroxide	12.1	68
Oxygen difluoride	12.7	-229
Otto fuel	10.5	77
Ozone difluoride	14.6	-297
Pentaborane	5.2	68
Perchloryl fluoride	12.0	68
Red fuming nitric acid (IRFNA)	12.5	68
RP-1	6.8	68
Tetranitromethane	13.6	78
UDMH	6.6	68
UDMH/hydrazine	7.5	68

NOTE:
[1] Conversion of quantities of propellant from gallons to pounds:
Pounds of propellant = Gallons X density of propellant in pounds per gallon

8-13. Contaminated Liquid Propellants

A. Caution shall be exercised in the storage and

handling of liquid propellants which are contaminated. Such contamination may increase the degree of hazard associated with the propellant.

B. Liquid propellants known to be contaminated or in a suspect condition shall be isolated and provided separate storage from all other propellants pending laboratory analysis for verification of contamination, and disposition requirements, if any.

CHAPTER 9

MISHAP REPORTING AND INVESTIGATION REQUIREMENTS

9-1. SCOPE

A. The ammunition, explosives, and chemical agent mishaps that shall be reported and investigated in accordance with this chapter are specified by inclosure 5 to DoD Instruction 6055.7, "Mishap Investigation, Reporting and Recordkeeping," December 16, 1981. Mishap reports submitted to DDESB shall be prepared in accordance with regulations implementing DoD Instruction 6055.7, and shall have control symbol number DD-M(AR)1020.

B. This chapter sets forth the minimum data to be included in all mishap reports submitted to the DDESB.

C. Serious mishaps reported to the DDESB under this requirement need not be reported separately to the Director for Safety and Occupational Health Policy, ODASD(EO&S) under the special reporting requirements of inclosure 3 to DoD Instruction 6055.7.

9-2. REPORT CLASSIFICATION

Mishap reports should be unclassifed whenever possible to facilitate appropriate dissemination of useful safety information to DoD Components, industry, and allied governments.

9-3. INITIAL REPORTS

A. Telephonic and electrically transmitted reports should include as much of the following data as may be immediately available.

1. Name and location of the reporting activity.
2. Name, title, and telephone number of person reporting, and of contact at the scene of the accident.
3. Location of mishap (activity, city, installation, building number or designation, road names, etc.).
4. Item nomenclature (Mk, Mod, FSC. FIIN, DODAC/NALC).
5. Quantity involved (number of items and net explosives weight).
6. Day, date, and local time of initial significant event and when discovered.
7. Description of significant events (Include type of operation involved).
8. Number of fatalities (military/DoD civilian/other civilian).
9. Number of persons injured (military/DoD civilian/other civilian).
10. Description of material damage (government/non-government).
11. Material damage cost (government/non-government).
12. Cause.
13. Action taken or planned (corrective, investigative, EOD assistance, etc.)
14. Effect on production, operation, mission, or other activity.
15. Details of any remaining chemical agent hazard, or contamination, if applicable.
16. Are any news media aware (Yes or No).

B. Regardless of format, mishap reports prepared or received in compliance with other directives of the DoD or its Components may be used to satisfy these reporting requirements whenever they contain similar data.

9-4. FOLLOW-UP REPORTS

A. Follow-up reports should be submitted to the DDESB via priority-precedence, electrically-transmitted message within 2 workdays after notification of an occurrence has been received and should contain any additional detailed information on the data elements contained in paragraph 9-3.

B. Regardless of format, supplemental mishap reports prepared or received in compliance with other directives of the DoD or its Components may also be used to satisfy the follow-up reporting requirement whenever they contain similar data.

9-5. INVESTIGATION REPORTS

A. Event circumstances. The following data, as applicable, shall be included as a part of mishap investigation reports. Chemical agent mishaps also require the inclusion of the data specified in paragraph 9-6 below.

1. Location, data, and local time.
2. Type of operation, transportation mode, etc., engaged in at time of the mishap (Include reference to applicable Standing Operating Procedure, Operating Instruction, Directive, Standard, etc.)
3. Description of mishap.
4. Quantity, type, lot number, configuration, and packaging of ammunition, explosives, or chemical agents involved in the mishap.
5. Type of reaction(s).
   a. Single - detonation, deflagration, fire, release, or activation.
   b. Multiple - detonation and fire, etc.
   c. Communication - fire caused fire, fire caused detonation, detonation caused detonation, etc. Time between events.
6. Possible or known causes.

B. Event effects. When appropriate, include photographs, colored whenever possible, maps, charts, overlays, etc., showing or listing the following data. A copy of aerial and ground photographs taken of the mishap site shall be submitted to the DDESB as soon as possible after the occurrence.

1. Number of persons killed or injured (military/DoD civilian/other civilian). Indicate cause of fatalities and injuries, and location of affected persons with respect to the mishap origin.
2. Property damage at the mishap origin (government/non-government).
3. Area containing property with complete destruction (more than 75%). Indicate the mishap origin and include a description of the damage and its cause.
4. Area containing property damage beyond economical repair (50 to 75%). Indicate the mishap origin, and a description of the damage and its cause.
5. Area containing repairable property damage (1 to 49%). Indicate event origin, and a description of the damage and its cause.
6. Radii of uniform and of irregular glass breakage. Where possible, include type and dimensions of glass broken at farthest point.
7. Locations and dimension of craters.

8. Distances from the mishap origin at which direct propagation occurred, and whether from blast, fragments, or firebrands.

9. Approximate number of pieces of debris in a 10,000 square-foot area centered at K9, K18, K24, K30, K40 and K50 distance radii. Consider directional effects when locating sample areas. Specify maximum distance at which debris were found.

10. Number and approximate size of fragments in a 10,000 square-foot area centered at K6, K9, K11, K18, K24, K30, K40 and K50 distance radii. Consider directional effects when locating sample area. Specify maximum distance to which fragments were found and reaction of fragments on impact (burned, detonated, disunited, etc.).

C. Factors contributing to or limiting event effects. When appropriate, describe the influence of the following factors on the mishap.

1. Environmental/meteorological - cloud cover, wind direction and velocity, temperature, relative humidity, EMR, electrostatic, etc.

2. Topography - hills, forests, lakes, etc.

3. Structural features at the mishap origin - exterior and interior walls/bulkheads, roofs/overheads, doors/hatches, cells or magazines, earth cover, barricades, etc.

4. Safety features, other than structural, at the mishap origin - remote controls, sprinkler and/or deluge systems, detectors, alarms, blast traps, suppressive shielding, etc.

5. Structures - position, orientation, and type construction of all structures, damaged or not, located within maximum radius of damage. When either the applicable intermagazine, intraline, or inhabited building distances are greater than the radius of actual damage, show the location, orientation, and type construction of all structures situated within the Q-D radii.

6. Vessels, vehicles, mobile equipment-location within maximum radius of damage, or if the Q-D requirements are greater, location within the K9, K18, K24, and K30.

7. Personnel-location within maximum radius of damage, or if the Q-D requirements are greater, location within K9, K18, K40, and K50.

8. Explosives, ammunition, and chemical agents - location, type, configuration, amounts, and protection provided within meximum radius of damage, or if the Q-D requirements are greater, location within the applicable magazine and intraline radii.

D. Analyses, conclusions, and recommendations.

9-6. CHEMICAL AGENT MISHAPS

In addition to the data required by paragraph 9-5 for ammunition and explosives mishaps, each chemical agent mishap investigation report shall contain the following information:

A. Injuries

1. The safety training that personnel received applicable to duty being performed at the time of the mishap.

2. The availability, type, and use of protective clothing.

3. A description of emergency measures taken or performed by individuals at the scene of the mishap.

4. A summary of applicable medical data.

5. A sketch showing locations where disabling injuries occurred, and indicating the distance and direction from the agent source.

B. Mishap Area. In addition to the environmental/meteorological data required by paragraph 9-5.C.1, indicate:

1. The facility filter types, and the facility ventilation and air turnover rates, etc.

2. The rate and manner of agent release and any other data used to determine the downwind hazard.

3. The status and disposition of chemical agent remaining at the mishap site.

4. The details of any remaining chemical agent hazard, and contamination if applicable.

CHAPTER 10

REAL PROPERTY CONTAMINATED WITH AMMUNITION AND EXPLOSIVES

10-1. Scope

This chapter contains those particular policies and procedures necessary to provide protection to personnel from accidental injury as a result of contamination of Department of Defense (DoD) real property with ammunition and explosives. It requires identification and control measures that are in addition to, not substitutes for, those generally applicable to DoD real property management. Contamination as used in this chapter refers in all cases to contamination with ammunition and explosives.

10-2. Policy

A. Every means possible must be given to the protection of the general public who may become exposed to hazards from contaminated real property currently or formerly under DoD ownership or control.

B. Permanent contamination of real property by final disposal of ammunition and explosives is prohibited. This prohibition extends to disposal by land burial; by discharge onto watersheds or into sewers, streams, lakes, or waterways. This policy does not preclude burial to control fragments during authorized destruction by detonation, or disposal by dumping in deep water in the open ocean when these procedures are authorized by the responsible DoD Component, and compliance with applicable statutes and regulations relative to environmental safeguards is assured.

C. DoD real property which is known to be contaminated with ammunition and explosives which could endanger the general public should not be released from DoD custody until the most stringent efforts have been made to assure appropriate protection of the public. Some contamination is, however, so extensive that removal of the hazard is beyond the scope of existing technology and resources.

10-3. Procedures

A. General

Some DoD real property is contaminated with ammunition and explosives due to its use as manufacturing areas, firing and impact ranges, and waste collection or disposal areas including pads, pits, basins, ponds, streams, burial sites and other locations incident to such operations.

B. Identification and Control

1. Permanent records, including master planning installation maps, shall clearly identify all areas contaminated with ammunition and explosives,

and be maintained by each DoD installation. These records shall indicate, to the extent possible, positive identification of the ammunition and explosives contamination by nomenclature, hazard, quantity, and exact locations. If the installation is inactivated, the records will be transferred to the office which the cognizant DoD Component designates to insure permanent retention.

2. All contaminated locations shall be appropriately placarded with permanent signs which prohibit entrance of unauthorized personnel. These signs shall be multi-lingual where appropriate. The responsible DoD Component shall periodically insure that such signs are restored and maintained in a legible condition.

3. Active firing ranges, demolition grounds, and explosives test areas will be assumed to be contaminated with unexploded ordnance or explosive material and controlled accordingly.

C. Land Disposal

1. Procedures for disposal of DoD real property are contained in DoD Directives and Federal Property Management Regulations.

2. DoD action correspondence or reports of excess contaminated real property shall state the extent of such contamination, any plans for decontamination, and the extent to which the property may be used safely without further decontamination.

3. Accountability and control of real property contaminated with ammunition and explosives may be transferred between DoD Components when ASD(MRA&L) approval is obtained and the requirements of 10 USC 2662 have been met. Such action must be accompanied by a like transfer of the permanent records of contamination.

4. Accountability and control of real property contaminated with ammunition or explosives shall not be transferred to agencies outside DoD, and the accountability for such contaminated real property shall remain vested in DoD until the property has been rendered innocuous. By innocuous, it is meant that it is reasonable to assume the real property is not contaminated with live ammunition or explosives to an extent that constitutes an unacceptable risk to the general public. When real property is reported to the disposal agency (GSA) after decontamination, information to indicate the nature and extent of the original contamination, and the decontamination methods used will be inclosed with the report of excess with the requirement that they be entered in the permanent land records of the civil jurisdiction in which the property is located.

5. Limited-use outgrants may be arranged with other government agencies for compatible use of contaminated real property such as wildlife refuges, safety zones for federal power facilities, or other purposes not

requiring entry except for personnel authorized by the DoD Component. These outgrants shall include all restrictions and prohibitions concerning use of the property to assure appropriate protection both of DoD personnel and the general public.

D. Decontamination Methods and Use Restrictions

1. Surface Clearing. Visual inspection and electronic detection instruments will be used to locate and remove unexploded ordnance located at or very near the surface. Subsequent use of the real property should be restricted to activities which do not require excavation of the surface such as wildlife preserves, sanitary land fills, and livestock grazing.

2. Minimum Depth. To be used where scarifying area is both possible and allowable. Mechanical procedures such as rake or windrower to a 6-inch depth may be used and followed up with magnet and rock picker. This procedure will clear the area of all metal fragments and unexploded ordnance on the surface or buried within the scarifying depth. Subsequent use should be restricted to activities requiring minimum disturbance of the surface such as limited agriculture or tree farming.

3. Specified Depth. Unexploded ordnance must be removed to depth below which any future soil disturbance is expected to be performed by the general public. Real property decontaminated by this method may be released for unrestricted use to the depth cleared. The reliability of this method is dependent upon:

a. A determination of the penetration characteristics of the unexploded ordnance known or suspected to be present in the soil to be decontaminated.

b. Testing of candidate detection instruments in the specific geographical, geological, and physical features present to determine reliable depth of detection for the types of ordnance suspected. An example of such a test is contained in DDESB TR 76-1, April 1976, Detection of Unexploded Ordnance.

4. Any certification clearance should list the known or suspected contaminates, the method of decontamination use, and restrictions, if any, for future use to include maximum safe depth of soil disturbance or excavation.

CHAPTER 11

HAZARD IDENTIFICATION FOR FIRE FIGHTING

11-1. Scope and Applicability

A. The purpose of this chapter is to establish standard fire fighting hazard identification measures to ensure a minimum practicable risk in fighting fires of ammunition and explosives. These identification measures are based on the classification of fires into four Fire Divisions (1 to 4) according to the hazard they present.

B. Other measures required in fire fighting such as the fire fighting procedures, training of fire fighting personnel, the use and maintenance of fire fighting equipment and vehicles, the provision of water supply and alarm systems, the first aid measures, and other specifics are outside the scope of this chapter and shall be the responsibility of the DoD Components.

C. The ammunition hazard symbols and supplemental symbols including chemical agent symbols, paragraph 11-4, are for fire fighting situations only and are not necessarily applicable to normal operating conditions.

D. The objective is to attain uniformity in the display of fire symbols to the maximum extent practicable, consistent with the requirements of the DoD Components. Accordingly, the identification measures contained herein will replace any existing fire hazard identification systems currently in use by the DoD Components in all situations and at all installations.

E. The Department of the Navy has been granted exceptions when required because of Service-peculiar procedures from implementing the new hazard identification system except in the situations where:

1. Responsibility for fire fighting is jointly shared by or assigned to two or all of the DoD Components.

2. Emergency assistance agreements with NATO or other DoD Components warrant unification of the fire hazard identification systems in use, in order to preclude confusion.

3. Joint tenancy situations, or host/tenant situations, wherein two or more separate fire hazard identification systems are now in use.

11-2. Fire Divisions

A. The Fire Divisions are synonymous with the Hazard Divisions 1.1 through 1.4 of chapter 5 and are serially numbered by Arabic figures from 1 to 4.

B. Fire Division 1 indicates the greatest hazard. The hazard decreases with ascending fire division numbers as follows:

Fire Division	Hazard involved
1	Mass detonation
2	Explosion with fragment hazard
3	Mass fire
4	Moderate fire

11-3. Fire Division Symbols

A. Each of the four fire divisions is indicated by a distinctive symbol in order to be recognized by fire fighting personnel approaching a scene of fire. The applicable fire division number is shown on each symbol. For the purpose of identifying these symbols from long range, the symbols differ in shape as follows:

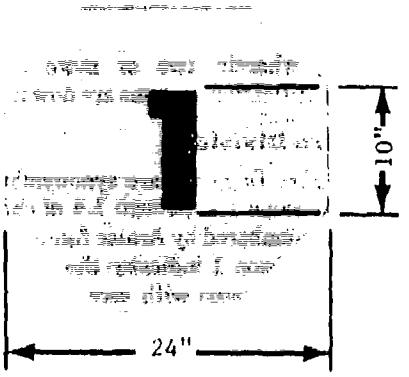
octagon shape	Fire Division Symbol 1
cross shape	Fire Division Symbol 2
inverted triangle shape	Fire Division Symbol 3
diamond shape	Fire Division Symbol 4

B. The color of all four symbols is orange. The color of each number identifying the applicable fire division is black. This requirement is in accordance with the color on NATO, UNO, and IMCO labels for Class 1 (Explosives).

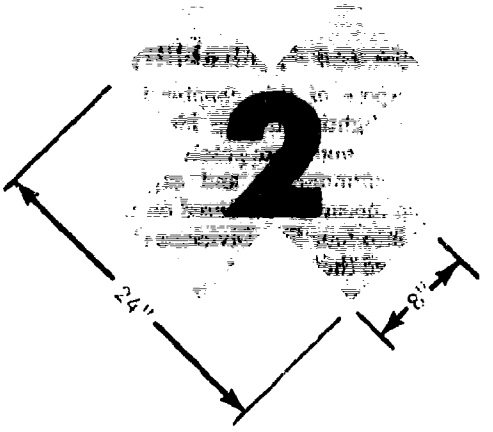
C. Shape and size of the four fire division symbols and numbers are shown in Figure 11-3.1. For application on doors or lockers inside buildings half-sized symbols may be used.

D. Posting of fire fighting symbols on nuclear, chemical, or conventional weapon storage sites is at

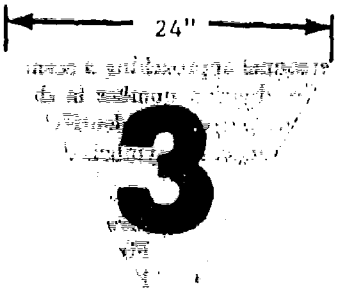
FIGURE 11-3.1 FIRE DIVISION SYMBOLS
(See Paragraph 11-3)



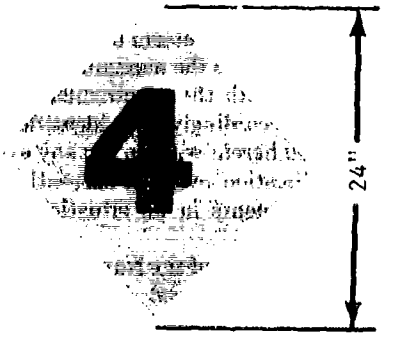
Class 1, Division 1



Class 1, Division 2



Class 1, Division 3



Class 1, Division 4

Color of Symbols: Orange
Numbers: Black 10" High and 2" Thick

the discretion of the DoD Components. This recognizes that under some conditions security considerations may make it undesirable to identify munitions with fire symbols at the actual storage locations.

E. At the option of the DoD Component, supplemental symbols to indicate special hazards, such as those of toxic chemicals, may be used in addition to the fire fighting symbols specified in this chapter (see fig. 11-4.2).

11-4. Chemical Agent and Ammunition Hazard Symbols

A. The storage of chemical agents and ammunition requires the use of chemical hazard symbols. These symbols will be used by themselves or in conjunction with fire symbols as appropriate.

B. The chemical hazard symbols are illustrated in Figure 11-4.1. Supplemental chemical hazard symbols are circular in shape and are yellow with black letters, and are illustrated in Figure 11-4.2. Paragraphs 11-4C through 11-4H, below, further describe these symbols, the hazards indicated by the symbols, and recommended protective clothing and equipment to be used for fighting fires. Protective clothing requirements for other than fire fighting situations will be determined by the DoD Components.

C. When the chemical hazard symbol ordering the wearing of full protective clothing (Symbol 1 of Figure 11-4.1) is colored with a red rim and figure, the symbol indicates the presence of highly toxic chemical agents which may cause death or serious damage to body functions. The following full protective clothing, identified as Set 1 in Figure 11-4.1 and column 3 of Table 11-4.1 should be used: M9 series protective gas mask or self-contained breathing apparatus (SCBA), impermeable suit, impermeable hood, impermeable boots, undergarments, coveralls, protective footwear, and impermeable gloves.

D. When the chemical hazard symbol ordering the wearing of full protective clothing (Symbol 1 of Figure 11-4.1) is colored with a yellow rim and figure, the symbol indicates the presence of harassing agents (riot control agents and smokes). The following protective clothing, identified as Set 2 in Figure 11-4.1 and column 4 of Table 11-4.1, should be used: M9 series protective gas mask or self-contained breathing apparatus (SCBA), coveralls, and protective gloves.

E. When the chemical hazard symbol ordering the wearing of full protective clothing (Symbol 1 of Figure 11-4.1) is colored with a white rim and figure, the symbol indicates the presence of white phosphorus and other spontaneously combustible material. The following protective clothing, identified as Set 3 in Figure 11-4.1 and column 5 of Table 11-4.1, should be used: flame-resistant coveralls, flame-resistant gloves, M9 series protective gas mask or self-contained breathing apparatus (SCBA).

F. The chemical hazard symbol ordering the wearing of breathing apparatus (Symbol 2 of Figure 11-4.1) indicates the presence of incendiary and readily flammable chemical agents which present an intense radiant heat hazard. Protective masks to prevent inhalation of smoke from burning incendiary mixtures should be used.

G. Fire fighting personnel equipped with normal heat-resistant clothing (bunker suit) and gas mask/self-contained breathing apparatus do not require the protective clothing identified as sets 2 and 3 when fighting fires involving material in which sets 2 or 3 are specified in table 11-4.1.

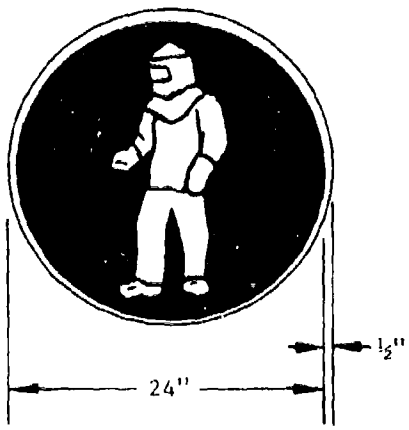
H. The chemical hazard symbol warning against applying water (Symbol 8 of Figure 11-4.1) indicates a dangerous reaction will occur if water is used in an attempt to extinguish fire.

I. The chemical hazard symbol prohibiting the use of water in fire fighting may be placed together with any one of the other symbols if required.

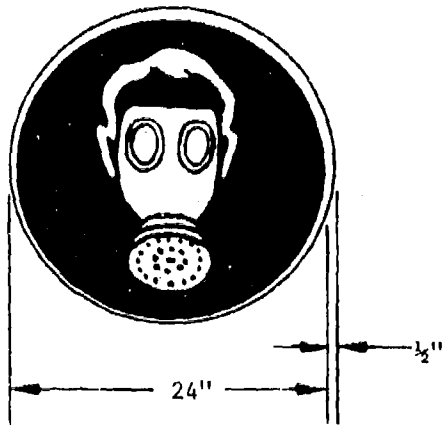
J. The supplemental chemical hazard symbols described in Figure 11-4.2 should be used with other symbols as required to identify chemical agents having special chemical hazards.

K. The chemical agents most used in ammunition, the compatibility groups of that ammunition, and the chemical hazard symbols required in storage are specified in Table 11-4.1.

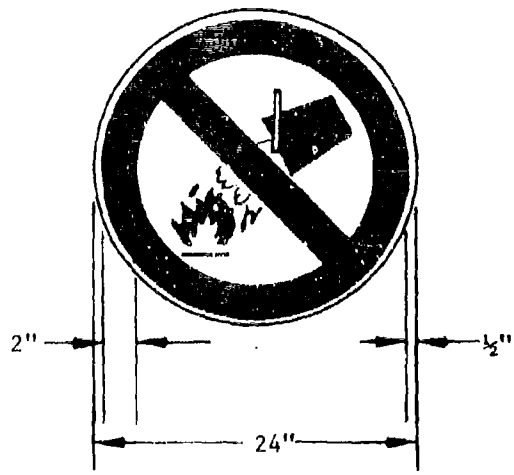
FIGURE 11-4.1 CHEMICAL HAZARD SYMBOLS
(See Paragraph 11-4)



1. Wear full protective clothing
Color of Symbol 1
The background of the symbol is blue
The figure and rim is:
Red for Set 1 Protective Clothing
Yellow for Set 2 Protective Clothing
White for Set 3 Protective Clothing



2. Wear Breathing Apparatus
Color of Symbol 2
The background of the symbol is blue
The figure and rim are white

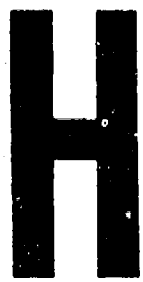


3. Apply no water
Color of Symbol 3
The background of the symbol is white, the circle and the diagonal stripe are red, the figures are black.

FIGURE 11–4.2
SUPPLEMENTAL CHEMICAL HAZARD SYMBOLS

1. G-Type Nerve Agents

2. VX Nerve Agents



3. H-Type Mustard Agents

All Symbols with Black Letters 12" High on 24" Dia. Yellow Circle.

TABLE 11-4.1—*Compatibility Group and Chemical Hazard Symbols Required for Storage of Chemical Ammunition and Substances*

Chemical Ammunition and Substances	Compatibility Group[1]	Full Protective Clothing			Breathing Apparatus	Apply No Water
		Set 1	Set 2	Set 3		
1	2	3	4	5	6	7
Toxic Agents[1]	K	X				
Tear Gas, O-Chlorobenzol	G		X			
Smoke, Titanium Tetrachioride (FM)	G		X			
Smoke, Sulphur trioxide-chlorosulphonic acid solution (FS)	G		X			
Smoke, Aluminum-zinc oxide-hexachloroethane (HC)	G				X	X
White Phosphorus (WP)	H			X		
White Phosphorus plasticized (PWP)	H			X		
Thermite or Thermate (TH)	G				X	X
Pyrotechnic Material (PT)	G				X	X
Calcium Phosphide	L				X	X
Signalling Smokes	G				X	
Isobutyl methacrylate with oil (IM)	J				X	
Napalm (NP)	J				X	
Triethylaluminum (TEA) (TPA)	L			X		X

[1] Toxic agents without explosive components which would normally be assigned to class 6 division 1 may be stored as compatibility group K.
[2] See Chapter 4.

11-5. Fire Fighting Measures

A. All fires starting in the vicinity of ammunition or explosives shall be reported and be fought immediately with all available means and without awaiting specific instructions. However, if the fire involves explosive material or is supplying heat to it, or if the fire is so large that it cannot be extinguished with the equipment at hand, the personnel involved shall evacuate and seek safety.

B. Fire fighters of ammunition and explosives fires shall have a thorough knowledge of the specific reactions of ammunition and explosives exposed to the heat or to the fire itself.

C. The fire fighting forces should be briefed before approaching the scene of the fire. They are to be informed of the known hazards and conditions existing at the scene of the fire before proceeding to the location of the fire.

D. All non-essential personnel shall be withdrawn from the scene of the fire to a distance that will provide adequate protection. The following distances are the minimum allowable and greater distances shall be used whenever possible:

Fire Symbol	Public Withdrawal Distance (feet)		
1	2,000	NOTE:	Use inhabited building distance for quantities greater than 100,000 lbs.
2	1,800		
3	600		Use inhabited building distance for quantities greater than 500,000 lbs.
4	300		

E. Fires involving ammunition and explosives will be fought according to their classification in fire divisions and the stage of the fires and the procedures specified by the respective DoD Component.

F. Ammunition containing both explosives and chemical agents (see Table 11-4.1) requires special attention and precautions in fire fighting. Such ammunition may belong to different fire divisions depending on the kind and quantity of explosives contained. Fires involving ammunition containing both explosives and chemical agents will be fought in accordance with their fire division characteristics, but also taking cognizance of the additional hazards resulting from the effects of the chemical agents and the associated special measures required in the fighting of those fires; e.g., fires of WP ammunition.

G. Special fire fighting regulations including withdrawal distances and times corresponding to the various symbols should be promulgated according to the needs and circumstances of the DoD Components.

CHAPTER 12

QUANTITY-DISTANCE STANDARDS FOR UNDERGROUND STORAGE

12–1. Scope

A. This chapter details quantity-distance standards for the storage of all types of ammunition and explosives in natural caverns or in excavated chambers below the natural ground surface.

B. The provisions of this chapter do not apply to storage in earth-covered magazines built above grade, standards for which appear elsewhere in this publication.

12–2. Storage Limitations

Ammunition and explosives of different kinds may be mixed in underground storage only to the extent permitted by the compatibility rules stated elsewhere in this publication. In addition, ammunition containing incendiary or smoke-producing fillers, flammable liquids or gels, or toxic agents, when stored underground, must be in single-chamber sites.

12–3. Protection Provided

A. *Chamber Spacing*

1. Minimum separation distances between chambers are intended to prevent communication of explosion by the mechanism of spalling of rock and subsequent impact on the contents of the chamber adjacent to one in which the initial explosion occurs. This ensures that the effects on structures and persons exposed at large distances will be limited to those from the contents of one chamber. If such minimum separation is not provided, the explosive quantities involved must be added together for purposes of determining effects at distant exposures.

2. If it is desired to limit the damage to stocks of ammunition in adjacent chambers by rock spall, separations larger than required to prevent explosion communication should be used. The recommended distances for this purpose depend upon rock type as well as explosive quantity.

B. *Exterior Distances.* Separation distances from stored ammunition and explosives to inhabited buildings and public traffic routes are intended to limit property damage and injury to persons caused by ground shock, air blast, or debris. The distances depend upon depth of overburden, type of soil or rock, and stored explosive quantity per unit chamber volume (loading density). The required inhabited building distance for a given quantity and storage condition is that corresponding to the dominant (farthest-reaching) effect. It is therefore the largest of the distances determined to be necessary for protection against the individual effects considered in turn. The required public traffic route distance will generally be sixty percent of the inhabited building distance so obtained.

12–4. Quantity-Distance Determinations

A. *Explosive Quantity.* Distances will be determined on the basis of the total quantity of explosives, propellants, pyrotechnics, and incendiary materials in the individual chambers, unless the total quantity is subdivided so as to prevent rapid communication of an incident from one subdivision to another (reference para. 3-2B2a). All of the propellants and explosive materials in ammunition of Class 1, Division 1 or 3 subject to involvement in a single incident will be assumed to contribute to the explosion yield as would an equal weight of TNT. Any significant differences in energy release per unit mass of the compositions involved from that of TNT must be taken into account, provided such differences are adequately supported by available data. A connected chamber storage site or cavern storage site containing material of Class 1, Division 1 or 3, or both, will be treated as a single-chamber site, unless explosion communication is prevented by adequate subdivision or chamber separation.

B. *Distance Measurement*

1. The chamber interval is the shortest distance between the natural walls of two adjacent chambers. The interval between chambers formed by subdivision of a cavern is the thickness of competent barrier constructed between them.

2. The thickness of overburden or earth cover over a chamber is the shortest distance from the

natural chamber ceiling to the natural ground surface.

3. Distances to inhabited buildings and public traffic routes will be measured as follows:

a. A distance determined by blast or debris issuing from a tunnel entrance at the ground surface will be measured from the tunnel entrance to the nearest wall or point of the location to be protected, using the extended centerline of the main passageway as a reference line for directional effects.

b. A distance determined by ground shock will be measured as the length of the straight line joining the nearest natural wall of a chamber containing ammunition to the nearest wall or point of the location to be protected.

c. A distance determined by blast from an uncontaminated explosion, or by surface ejecta, will be measured from the point on the natural ground surface nearest the natural chamber ceiling to the nearest wall or point of the location to be protected.

C. *Chamber Interval*

1. The separation distance D_{cp} between chambers required to prevent explosion communication by impact of spalled rock will be calculated from $D_{cp} = 1.5W^{1/3}$, where D_{cp} is in feet and W is the net weight in pounds of all the propellants and explosives in ammunition of Class 1, Division 1 or 3 in one chamber, adjusted for any significant differences in energy release from that of TNT as required by paragraph 12-4A above. The chamber separation distance will not, however, be less than 15 feet. Chamber entrances at the ground surface, or entrances to branch tunnels off the same side of a main passageway, must be separated by a distance not less than the chamber interval as determined above. Entrances to branch tunnels off opposite sides of a main passageway must be separated by at least twice the width of the main passageway.

2. The chamber separation D_{cd} required to prevent damage to stored ammunition will be calculated from the following formulas:

a. $D_{cd} = 3.5W^{1/3}$ (sandstone),
b. $D_{cd} = 4.3W^{1/3}$ (limestone), or
c. $D_{cd} = 5.0W^{1/3}$ (granite),

where D_{cd} is in feet and W is in pounds of propellants and explosives in ammunition of Class 1, Divisions 1 and 3.

3. The separation distances D_{cd} to prevent damage to stored ammunition have been computed and are listed in Table 12-4.1.

4. Chambers separated by at least the distances required in paragraph 12-4C1 above may be used to the limit of their physical capacity to store ammunition of Class 1, Divisions 2 and 4, except for specific Division 2 items having special stacking and NEW restrictions (see paragraph 5-4B). If stored in the same chamber with ammunition of Class 1, Divisions 1 or 3, however, the propellant and explosive content of ammunition of Divisions 2 and 4 must be added to that of the other divisions to obtain the net explosive quantity for distance determinations.

D. *Inhabited Building Distance.* The inhabited building distance will be taken as the largest of the distances required for protection against ground shock, air blast, or debris, determined by computations carried out as described in the following paragraphs. For the convenience of the user, each of the functions to be evaluated is tabulated; straight-line interpolation is permitted in all tables.

1. For protection of residential buildings against significant structural damage by ground shock, the maximum particle velocity induced in the ground at the building site must not exceed the following values:

2.4 ips in sand, gravel, or moist clay (sound speed 3000 to 5000 fps),
4.5 ips in soft rock (sound speed 6000 to 10,000 fps), and
9.0 ips in hard rock (sound speed 15,000 to 20,000 fps).

Unless data specific to the site being evaluated are available regarding ground shock attenuation in the earth materials between the potential explosion source and the exposed site, the required inhabited building distance D_{ig} will be calculated from the appropriate one of the following expressions:

a. $D_{ig} = 2.1f_gW^{1/3}$ (sand, gravel, moist clay),
b. $D_{ig} = 11.1f_gW^{1/3}$ (soft rock), or
c. $D_{ig} = 12.5f_gW^{1/3}$ (hard rock),

where D_{ig} is in feet and W is the explosive quantity in pounds determined in accordance with paragraph 12-4A. The dimensionless multiplier f_g is a decoupling factor, given as a function of loading density by the formula $f_g = (4/15)w^{0.3}$ where w is the explosive quantity W in pounds divided by the chamber volume in cubic feet.

Values of D_{ig}/f_g are listed in Table 12-4.2. To obtain an inhabited building distance D_{ig}, a numerical value read from the appropriate column of Table 12-4.2 must be multiplied by the value of f_g read from Table 12-4.7, Column 2.

2. Distances required for protection of inhabited areas against the effects of air blast and surface debris depend on the depth of overburden, or earth cover, over the storage chamber. The minimum

depth C_c required to ensure containment of an explosion (except for venting of gases through tunnels), and to ensure that no significant disruption of surface material occurs, will be calculated from $C_c = 3.5W^{1/3}$, where W is the explosive quantity in pounds determined in accordance with paragraph 12-4A. For depths of overburden less than this, the effects of both air blast and the projection of debris must be considered. In particular, if the actual cover depth C is less than C_v, given by $C_v = 0.5W^{1/3}$, blast at large distances may not be suppressed appreciably below that from an explosion on the surface. In that case, inhabited building and public traffic route distances for aboveground storage, specified elsewhere in this publication, must be utilized, including any applicable minimum distances required for protection against fragments from ammunition of Class 1, Division 1, 2, or 3. Values of C_v and C_c are listed in Table 12-4.3.

3. If the depth of overburden C equals or exceeds C_v calculated from the formula above, the effects of blast issuing from entrances at the ground surface must be considered. In general these effects will be functions of direction relative to the axis of the passageway where it emerges at the ground surface. In the absence of data and analysis on far-field blast propagation specific to the site being evaluated, five sectors will be defined as shown in Figure 12-4.1. In each sector the distance required for protection of inhabited areas against blast will be taken as proportional to the cube root of a reduced net explosive quantity W_r, defined by $W_r = W/nk$ where n = 1 or 2, and k = 1 or 3, as follows:

n = 1, if the storage site has not more than one entrance at the ground surface;

n = 2, if the site has two or more entrances, and if the blast waves issuing from those entrances are not expected to mutually reinforce owing to their proximity;

k = 3, if the ammunition is stored in a chamber on a branch passageway of cross-sectional area not more than half that of the main passageway to which it is connected, and of length not less than one-third the chamber interval D_{cp} calculated in paragraph 12-4C1 above;

k = 1, otherwise.

Whether mutual reinforcement of blast issuing from two or more entrances occurs will be determined by carrying out the subsequent analysis on the tentative assumption that n = 1. If none of the sectors from one entrance overlaps any of those from another, the interaction may be ignored and the distances determined by repeating the analysis with n = 2.

With the foregoing definitions, the distances D_{i1}, D_{i2}, ... D_{i5} required for protection of inhabited areas against blast in the sectors defined in Figure 12-4.1 will be calculated as follows:

$D_{i1} = 19W_r^{1/3}$, $180 \geq \theta \geq 120$ deg

$D_{i2} = 33W_r^{1/3}$, $120 > \theta \geq 90$ deg

$D_{i3} = 50W_r^{1/3}$, $90 > \theta \geq 60$ deg

$D_{i4} = 68W_r^{1/3}$, $60 > \theta \geq 30$ deg

$D_{i5} = 76W_r^{1/3}$, $30 > \theta \geq 0$ deg

where θ is the horizontal angle measured from the centerline of the main passageway extended outward from the entrance, and where W_r is the net explosive weight in pounds determined in accordance with paragraph 12-4A, reduced by the factors n and k which depend upon the geometry of the storage site as specified above. Values of D_{ih}, which stands for the distances D_{i1}, D_{i2}, ... D_{i5} computed from the formulas above, are listed in Table 12-4.4

4. If the depth of overburden C is less than C_c calculated from the first of the formulas given in paragraph 12-4D2, the effects of debris projected from the ground surface above the explosion site must be evaluated. The distance D_{id} required for the protection of inhabited areas against such debris will be calculated from

$$D_{id} = f_d f_c W^{0.41}$$

where W is the explosive quantity in pounds determined in accordance with paragraph 12-4A, f_c is a function of the scaled depth of overburden $C/W^{1/3}$, and f_d is a function of the chamber loading density w. The function of earth cover, f_c, depends on the type of rock in the vicinity of the storage chamber. It is given graphically in Figure 12-4.2 for hard rock (e.g., granite, limestone) and for soft rock (e.g., sandstone). The factor f_d is given by the formula

$$f_d = (3/5)w^{0.18}$$

where the loading density w is expressed in pounds of explosive per cubic foot of chamber volume.

Values of D_{id}/f_d are listed in Table 12-4.5 for hard rock and in Table 12-4.6 for soft rock, for values of scaled overburden thickness $C/W^{1/3}$ given at the heads of the columns. These values of scaled cover correspond to the circled points on the curves in Figure 12-4.2, and are such that straight-line interpolation between columns of the tables is a satisfactory procedure for intermediate values of scaled cover.

To obtain a distance D_{id}, the scaled depth of overburden $C/W^{1/3}$ must be calculated, where C is the depth of overburden in feet measured as the short-

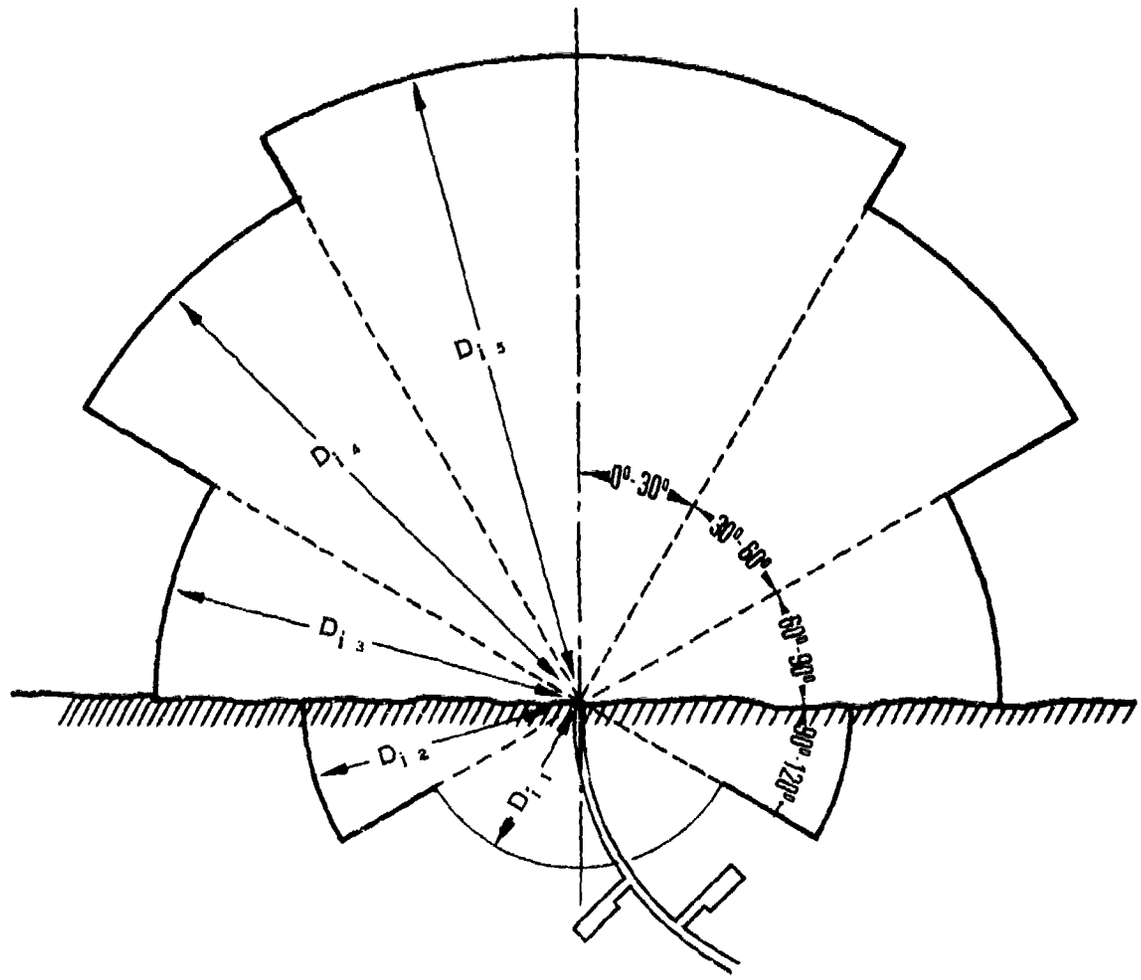


FIGURE 12—4.1
BLAST PROTECTION SECTORS FOR INHABITED AREAS

est distance from the natural chamber ceiling to the natural ground surface above, and W is the explosive quantity in pounds determined in accordance with paragraph 12-4A. The appropriate table, 12-4.5 or 12-4.6, can be entered with the numerical value determined for the scaled depth of overburden, $C/W^{1/3}$, interpolating between columns if necessary.

The value obtained from Table 12-4.5 or 12-4.6 must be multiplied by the value of f_d read from Table 12-4.7, column 3 in order to obtain the distance D_{id} required for protection of inhabited areas against debris damage.

The distance D_{id} determined by the foregoing procedure will be applied in all directions from the point on the natural ground surface nearest to the chamber, except that in the sector 15 degrees to either side of the centerline of the main passageway, the distance will not be less than 2,000 feet measured from the entrance.

E. *Public Traffic Route Distance.* The distance to any public right-of-way will be taken as sixty percent of the inhabited building distance determined in accordance with paragraph 12-4D above.

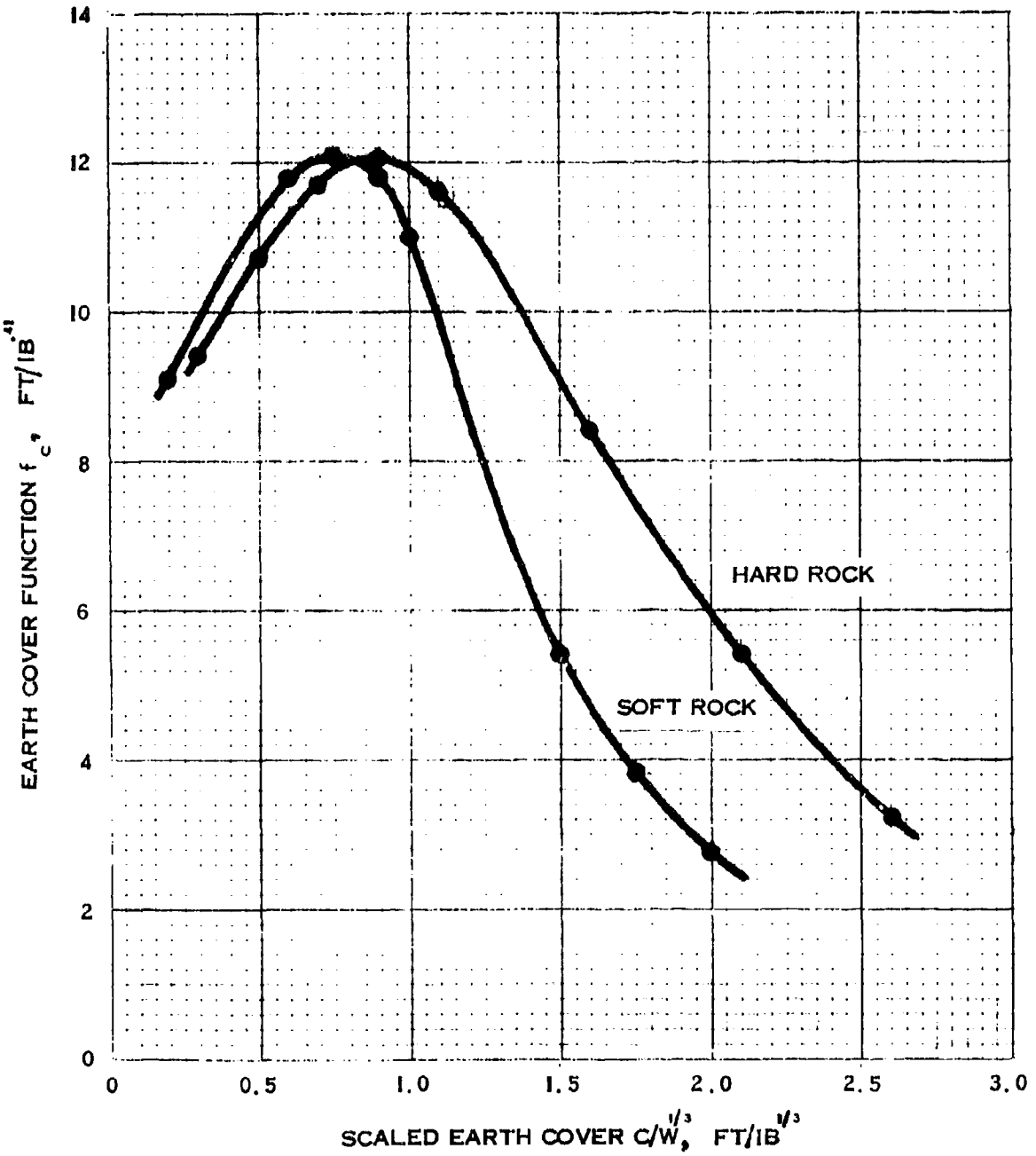


FIGURE 12–4.2—DEBRIS DISPERSAL FUNCTIONS

TABLE 12-4.1—*Chamber Separation*

Weight, lb		R_{cp}, ft	Dcd, ft		
Over	Not Over	$1.5W^{1/3}$	$3.5W^{1/3}$	$4.3W^{1/3}$	$5.0W^{1/3}$
0	1,000	15.0	35	43	50
1,000	1,200	16.0	37	46	54
1,200	1,400	17.0	39	48	56
1,400	1,600	17.5	41	50	58
1,600	1,800	18.0	43	52	60
1,800	2,000	19.0	44	54	62
2,000	2,500	20.5	48	58	68
2,500	3,000	21.5	50	62	72
3,000	3,500	23.0	54	66	76
3,500	4,000	24.0	56	68	80
4,000	4,500	25	58	70	82
4,500	5,000	26	60	74	86
5,000	6,000	27	64	78	90
6,000	7,000	29	66	82	96
7,000	8,000	30	70	86	100
8,000	9,000	31	72	90	105
9,000	10,000	32	76	92	110
10,000	12,000	34	80	98	115
12,000	14,000	36	84	105	120
14,000	16,000	38	88	110	125
16,000	18,000	39	92	115	130
18,000	20,000	41	96	115	135
20,000	25,000	44	100	125	145
25,000	30,000	47	110	135	155
30,000	35,000	49	115	140	165
35,000	40,000	52	120	145	170
40,000	45,000	54	125	155	180
45,000	50,000	56	130	160	185
50,000	60,000	58	135	170	195
60,000	70,000	62	145	175	205
70,000	80,000	64	150	185	215
80,000	90,000	68	155	195	225
90,000	100,000	70	160	200	230
100,000	120,000	74	175	210	245
120,000	140,000	78	180	225	260
140,000	160,000	82	190	235	270
160,000	180,000	84	200	245	280
180,000	200,000	88	205	250	290
200,000	250,000	94	220	270	310
250,000	300,000	100	235	290	330
300,000	350,000	105	245	300	350
350,000	400,000	110	260	320	370
400,000	450,000	115	270	330	380
450,000	500,000	120	280	340	400
500,000	600,000	125	300	360	420
600,000	700,000	135	310	380	440
700,000	800,000	140	320	400	460
800,000	900,000	145	340	420	480

TABLE 12-4.2—*Distances to Protect Against Ground Shock.*

Weight, lb		D_{ig}/I_g		
Over	Not Over	$2.1W^{1/3}$	$11.1W^{1/3}$	$12.5W^{1/3}$
0	1,000	45	240	270
1,000	1,200	49	260	290
1,200	1,400	52	280	310
1,400	1,600	56	290	330
1,600	1,800	58	310	350
1,800	2,000	62	330	370

TABLE 12-4.2—*Distances to Protect Against Ground Shock* (Continued)

Weight, lb		D_{ig}/I_g		
Over	Not Over	$2.1W^{1/3}$	$11.1W^{1/3}$	$12.5W^{1/3}$
2,000	2,500	68	360	400
2,500	3,000	74	390	440
3,000	3,500	78	420	470
3,500	4,000	84	440	500
4,000	4,500	88	470	520
4,500	5,000	92	490	560
5,000	6,000	100	540	600
6,000	7,000	105	560	640
7,000	8,000	115	600	680
8,000	9,000	120	640	720
9,000	10,000	125	660	740
10,000	12,000	135	720	820
12,000	14,000	145	780	880
14,000	16,000	155	820	920
16,000	18,000	165	860	980
18,000	20,000	170	900	1,000
20,000	25,000	190	1,000	1,150
25,000	30,000	205	1,100	1,200
30,000	35,000	220	1,150	1,300
35,000	40,000	235	1,250	1,400
40,000	45,000	245	1,300	1,450
45,000	50,000	260	1,350	1,550
50,000	60,000	280	1,500	1,650
60,000	70,000	300	1,600	1,800
70,000	80,000	320	1,700	1,900
80,000	90,000	330	1,750	2,000
90,000	100,000	350	1,850	2,100
100,000	120,000	380	2,000	2,250
120,000	140,000	410	2,150	2,400
140,000	160,000	430	2,300	2,600
160,000	180,000	450	2,400	2,700
180,000	200,000	480	2,500	2,800
200,000	250,000	520	2,800	3,100
250,000	300,000	580	3,000	3,400
300,000	350,000	620	3,200	3,600
350,000	400,000	640	3,400	3,900
400,000	450,000	680	3,600	4,100
450,000	500,000	720	3,800	4,300
500,000	600,000	780	4,100	4,600
600,000	700,000	840	4,400	5,000
700,000	800,000	880	4,700	5,200
800,000	900,000	940	4,900	5,600

TABLE 12-4.3—*Depth of Overburden*

Weight, lb		C_v, ft	C_c, ft
Over	Not Over	$0.5W^{1/3}$	$3.5W^{1/3}$
0	1,000	5.0	35
1,000	1,200	5.4	37
1,200	1,400	5.6	39
1,400	1,600	5.8	41
1,600	1,800	6.0	43
1,800	2,000	6.2	44
2,000	2,500	6.8	48
2,500	3,000	7.2	50
3,000	3,500	7.6	54
3,500	4,000	8.0	56
4,000	4,500	8.2	58
4,500	5,000	8.6	60

TABLE 12-4.3—*Depth of Overburden*—Continued

Weight, lb		C_v, ft	C_c, ft
Over	Not Over	$0.5W^{1/3}$	$3.5W^{1/3}$
5,000	6,000	9.0	64
6,000	7,000	9.6	66
7,000	8,000	10.0	70
8,000	9,000	10.5	72
9,000	10,000	11.0	76
10,000	12,000	11.5	80
12,000	14,000	12.0	84
14,000	16,000	12.5	88
16,000	18,000	13.0	92
18,000	20,000	13.5	96
20,000	25,000	14.5	100
25,000	30,000	15.5	110
30,000	35,000	16.5	115
35,000	40,000	17.0	120
40,000	45,000	18.0	125
45,000	50,000	18.5	130
50,000	60,000	19.5	135
60,000	70,000	20.5	145

TABLE 12-4.3—*Depth of Overburden*

Weight, lb		C_v, ft	C_c, ft
Over	Not Over	$0.5W^{1/3}$	$3.5W^{1/3}$
70,000	80,000	21.5	150
80,000	90,000	22.5	155
90,000	100,000	23.0	160
100,000	120,000	24.5	175
120,000	140,000	26	180
140,000	160,000	27	190
160,000	180,000	28	200
180,000	200,000	29	205
200,000	250,000	31	220
250,000	300,000	33	235
300,000	350,000	35	245
350,000	400,000	37	260
400,000	450,000	38	270
450,000	500,000	40	280
500,000	600,000	42	300
600,000	700,000	44	310
700,000	800,000	46	320
800,000	900,000	48	340

TABLE 12-4.4—*Distances to Protect Against Air Blast*

W_T = W/nk, lb		D_{hb}, ft				
		120–180	90–120	60–90	30–60	0–30 deg
Over	Not Over	$19W_T^{1/3}$	$33W_T^{1/3}$	$50W_T^{1/3}$	$68W_T^{1/3}$	$76W_T^{1/3}$
0	1,000	190	330	500	680	760
1,000	1,200	200	350	540	720	800
1,200	1,400	215	370	560	760	860
1,400	1,600	220	390	580	800	880
1,600	1,800	230	400	600	820	920
1,800	2,000	240	420	620	860	960
2,000	2,500	260	450	680	920	1,050
2,500	3,000	270	480	720	980	1,100
3,000	3,500	290	500	760	1,050	1,150
3,500	4,000	300	520	800	1,100	1,200
4,000	4,500	310	540	820	1,100	1,250
4,500	5,000	320	560	860	1,150	1,300
5,000	6,000	350	600	900	1,250	1,400
6,000	7,000	360	640	960	1,300	1,450
7,000	8,000	380	660	1,000	1,350	1,500
8,000	9,000	400	680	1,050	1,400	1,600
9,000	10,000	410	720	1,100	1,450	1,650
10,000	12,000	430	760	1,150	1,550	1,750
12,000	14,000	460	800	1,200	1,650	1,850
14,000	16,000	480	840	1,250	1,700	1,900
16,000	18,000	500	860	1,300	1,800	2,000
18,000	20,000	520	900	1,350	1,850	2,050
20,000	25,000	560	960	1,450	2,000	2,200
25,000	30,000	600	1,050	1,550	2,100	2,350
30,000	35,000	620	1,100	1,650	2,200	2,500
35,000	40,000	640	1,150	1,700	2,350	2,600
40,000	45,000	680	1,150	1,800	2,400	2,700
45,000	50,000	700	1,200	1,850	2,500	2,800
50,000	60,000	740	1,300	1,950	2,700	3,000
60,000	70,000	780	1,350	2,050	2,800	3,100
70,000	80,000	820	1,400	2,150	2,900	3,300
80,000	90,000	860	1,500	2,250	3,000	3,400
90,000	100,000	880	1,550	2,300	3,200	3,500
100,000	120,000	940	1,650	2,450	3,400	3,700

TABLE 12-4.4—*Distances to Protect Against Air Blast* (Cont'd)

W_F = Wlnk, lb		$D_{lb,ft}$				
Over	Not Over	120-180	90-120	60-90	30-60	0-30 deg
		$18W_F^{1/3}$	$33W_F^{1/3}$	$50W_F^{1/3}$	$68W_F^{1/3}$	$76W_F^{1/3}$
120,000	140,000	980	1,700	2,600	3,500	3,900
140,000	160,000	1,050	1,800	2,700	3,700	4,100
160,000	180,000	1,050	1,850	2,800	3,800	4,300
180,000	200,000	1,100	1,950	2,900	4,000	4,400
200,000	250,000	1,200	2,100	3,100	4,300	4,800
250,000	300,000	1,250	2,200	3,300	4,600	5,000
300,000	350,000	1,350	2,350	3,500	4,800	5,400
350,000	400,000	1,400	2,450	3,700	5,000	5,600
400,000	450,000	1,450	2,500	3,800	5,200	5,800
450,000	500,000	1,500	2,600	4,000	5,400	6,000
500,000	600,000	1,600	2,800	4,200	5,800	6,400
600,000	700,000	1,700	2,900	4,400	6,000	6,800
700,000	800,000	1,750	3,100	4,600	6,400	7,000
800,000	900,000	1,850	3,200	4,800	6,600	7,400

TABLE 12-4.5—*Distances to Protect Against Hard Rock Debris*

Weight, lb		D_{id}/f_d, ft (Hard Rock), for $C/W^{1/3}$ =							
Over	Not Over	.30	.50	.70	.90	1.10	1.60	2.10	2.60 ft/lb$^{1/3}$
0	1,000	160	180	200	205	195	145	92	54
1,000	1,200	170	195	215	220	210	155	98	58
1,200	1,400	185	210	230	236	225	165	105	62
1,400	1,600	195	220	240	250	240	175	110	66
1,600	1,800	205	230	250	260	250	180	115	70
1,800	2,000	210	240	260	270	260	190	120	72
2,000	2,500	230	260	290	300	290	210	135	80
2,500	3,000	250	290	310	320	310	225	145	86
3,000	3,500	270	300	330	340	330	240	155	90
3,500	4,000	280	320	350	360	350	250	160	96
4,000	4,500	300	340	370	380	360	260	170	100
4,500	5,000	310	350	380	400	380	280	175	105
5,000	6,000	330	380	410	430	410	300	190	115
6,000	7,000	350	400	440	460	440	320	205	120
7,000	8,000	370	430	470	480	460	330	215	125
8,000	9,000	390	450	490	500	480	350	225	135
9,000	10,000	410	470	520	520	500	370	235	140
10,000	12,000	440	500	560	560	540	400	250	150
12,000	14,000	470	540	580	600	580	420	270	160
14,000	16,000	500	560	620	640	620	440	290	170
16,000	18,000	520	600	640	680	640	470	300	180
18,000	20,000	540	620	680	700	680	490	310	185
20,000	25,000	600	680	740	760	740	540	340	205
25,000	30,000	640	740	800	820	800	580	370	220
30,000	35,000	680	780	860	880	840	620	390	235
35,000	40,000	720	820	900	940	900	640	420	245
40,000	45,000	760	860	940	980	940	680	440	260
45,000	50,000	800	900	980	1,000	980	700	460	270
50,000	60,000	860	980	1,050	1,100	1,050	760	490	290
60,000	70,000	920	1,050	1,150	1,150	1,100	820	520	310
70,000	80,000	960	1,100	1,200	1,250	1,200	860	560	330
80,000	90,000	1,000	1,150	1,250	1,300	1,250	900	580	340
90,000	100,000	1,050	1,200	1,300	1,350	1,300	940	600	360
100,000	120,000	1,150	1,300	1,400	1,450	1,400	1,000	660	390
120,000	140,000	1,200	1,400	1,500	1,550	1,500	1,100	700	410
140,000	160,000	1,300	1,450	1,600	1,650	1,600	1,150	740	440
160,000	180,000	1,350	1,550	1,650	1,750	1,650	1,200	780	460
180,000	200,000	1,400	1,600	1,750	1,800	1,750	1,250	800	480

TABLE 12-4.5—*Distances to Protect Against Hard Rock Debris* (Cont'd)

Weight, lb		D_{id}/f_d, ft (Hard Rock), for $C/W^{1/3}$ =							
Over	Not Over	.30	.50	.70	.90	1.10	1.30	2.10	
200,000	250,000	1,550	1,750	1,900	2,000	1,900	1,350	880	520
250,000	300,000	1,650	1,900	2,050	2,150	2,050	1,500	960	560
300,000	350,000	1,750	2,000	2,200	2,250	2,200	1,600	1,000	600
350,000	400,000	1,850	2,100	2,300	2,400	2,300	1,650	1,050	640
400,000	450,000	1,950	2,200	2,450	2,500	2,400	1,750	1,100	666
450,000	500,000	2,050	2,300	2,500	2,600	2,500	1,800	1,150	700
500,000	600,000	2,200	2,500	2,700	2,800	2,700	1,950	1,250	740
600,000	700,000	2,350	2,700	2,900	3,000	2,900	2,100	1,350	800
700,000	800,000	2,450	2,800	3,100	3,200	3,100	2,200	1,400	840
800,000	900,000	2,600	3,000	3,200	3,300	3,200	2,300	1,500	880

TABLE 12-4.6—*Distances to Protect Against Soft Rock Debris*

Weight, lb		D_{id}/f_d, ft (Soft Rock), for $C/W^{1/3}$ =							
Over	Not Over	.20	.60	.75	.90	1.00	1.50	1.75	2.00 ft/lb$^{1/3}$
0	1,000	155	200	205	200	185	92	64	48
1,000	1,200	165	215	220	215	200	98	70	52
1,200	1,400	175	230	235	230	215	105	74	54
1,400	1,600	185	245	250	245	225	110	78	58
1,600	1,800	195	260	260	260	240	115	82	60
1,800	2,000	205	270	270	270	250	120	86	64
2,000	2,500	225	290	300	290	270	135	94	70
2,500	3,000	240	310	320	310	290	145	100	74
3,000	3,500	260	330	340	330	310	155	110	80
3,500	4,000	270	350	360	350	330	160	115	84
4,000	4,500	290	370	380	370	350	170	120	88
4,500	5,000	300	390	400	390	360	175	125	92
5,000	6,000	320	420	430	420	390	190	135	100
6,000	7,000	340	450	460	450	410	205	145	105
7,000	8,000	360	470	480	470	440	215	150	110
8,000	9,000	380	490	500	490	460	225	160	115
9,000	10,000	400	520	520	520	480	235	165	120
10,000	12,000	430	560	560	560	520	250	180	130
12,000	14,000	460	600	600	600	560	270	190	140
14,000	16,000	480	620	640	620	580	290	200	150
16,000	18,000	500	660	680	660	620	300	210	155
18,000	20,000	520	680	700	680	640	310	220	160
20,000	25,000	580	740	760	740	700	340	240	180
25,000	30,000	620	800	820	800	760	370	260	190
30,000	35,000	660	860	880	860	800	390	280	205
35,000	40,000	700	900	940	900	840	420	290	215
40,000	45,000	740	960	980	960	880	440	310	225
45,000	50,000	760	1,000	1,000	1,000	920	460	320	235
50,000	60,000	820	1,050	1,100	1,050	1,000	490	350	250
60,000	70,000	880	1,150	1,150	1,150	1,050	520	370	270
70,000	80,000	940	1,200	1,250	1,200	1,150	560	390	290
80,000	90,000	980	1,250	1,300	1,250	1,200	580	410	300
90,000	100,000	1,000	1,300	1,350	1,300	1,250	600	430	310
100,000	120,000	1,100	1,450	1,450	1,450	1,350	660	460	340
120,000	140,000	1,150	1,500	1,550	1,500	1,400	700	490	360
140,000	160,000	1,250	1,600	1,650	1,600	1,500	740	520	380
160,000	180,000	1,300	1,700	1,750	1,700	1,550	780	540	400
180,000	200,000	1,350	1,750	1,800	1,750	1,650	800	560	420
200,000	250,000	1,500	1,950	2,000	1,950	1,800	880	620	460
250,000	300,000	1,600	2,100	2,150	2,100	1,950	960	660	490
300,000	350,000	1,700	2,200	2,250	2,200	2,050	1,000	720	520
350,000	400,000	1,800	2,350	2,400	2,350	2,200	1,050	760	560
400,000	450,000	1,900	2,450	2,500	2,450	2,300	1,100	780	580
450,000	500,000	2,000	2,600	2,600	2,600	2,400	1,150	820	600

TABLE 12-4.6—*Distances to Protect Against Soft Rock Debris* (Cont'd)

Weight, lb		D_d/f_d, (Soft Rock), for $C/W^{1/3}$ =							
Over	Not Over	.20	.60	.75	.90	1.00	1.50	1.75	2.00 ft/lb$^{1/3}$
500,000	600,000	2,150	2,800	2,800	2,800	2,600	1,250	880	660
600,000	700,000	2,250	2,900	3,000	2,900	2,700	1,350	940	700
700,000	800,000	2,400	3,100	3,200	3,100	2,900	1,400	1,000	740
800,000	900,000	2,500	3,300	3,300	3,300	3,000	1,500	1,050	780

TABLE 12-4.7—*Functions of Loading Density*

w, pcf	f_g	f_d
	$0.287w^{.80}$	$0.600w^{.18}$
1.0	.27	.60
1.2	.28	.62
1.4	.29	.64
1.6	.31	.65
1.8	.32	.67
2.0	.33	.68
2.5	.35	.71
3.0	.37	.73
3.5	.39	.75
4.0	.40	.77
4.5	.42	.79
5	.43	.80
6	.46	.83
7	.48	.85
8	.50	.87
9	.52	.89
10	.53	.91
12	.56	.94
14	.59	.96
16	.61	.99
18	.63	1.01
20	.66	1.03
25	.70	1.07
30	.74	1.11
35	.77	1.14
40	.81	1.17
45	.84	1.19
50	.86	1.21
60	.91	1.25
70	.95	1.29
80	.99	1.32
90	1.03	1.35
100	1.06	1.37

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CHAPTER 13

PERSONNEL PROTECTION

13.1 SCOPE AND APPLICATION

This chapter establishes blast, fragments, and thermal hazards protection principles and applies to all operations/facilities where workers are exposed to ammunition/explosives hazards during industrial, processing, manufacturing, and more routine operations.

13.2 HAZARD ASSESSMENT

Assessment of risk shall be performed on all new or modified industrial operations/facilities involving ammunition/explosives. Based upon this assessment, engineering design criteria for the facility/operation will be developed for use in the selection of appropriate equipment, shielding, engineering controls and protective clothing for workers. The assessment should include such factors as (1) initiation sensitivity; (2) quantity of materials; (3) heat output; (4) rate of burning; (5) potential ignition sources; (6) protection capabilities of shields, various types of clothing, and fire protection systems; and (7) personnel exposure with special consideration given to the respiratory and circulatory damage to be expected by inhalation of hot vapors and the toxicological effects due to inhalation of combustion products.

13.3 PERMISSIBLE EXPOSURES

a. Workers must be provided protection from potential blast overpressures, hazardous fragments, and thermal effects, with applicable respiratory and circulatory hazards, when assessments performed in compliance with paragraph 13.2 indicate the probability of accidental explosion producing overpressures, hazardous fragments, and accidental flash fires producing thermal hazards are above an acceptable risk level as determined on a case-by-case basis by the DoD Component.

b. Protection afforded at the nearest work station must be capable of limiting incident blast overpressure to 2.3 psi, fragments to energies of less than 58 ft-lb, and thermal fluxes to 0.3 calories per square centimeter per second. Shields complying with MIL-STD-398 are acceptable protection.

13.4 PROTECTIVE MEASURES

Worker protection requirements of paragraph 13.3 may be achieved in one or more of the following ways:

a. Elimination or positive control of ignition/initiation stimuli.

b. Sufficient distance or barricades to protect from blast and/or fragments.

c. In those areas of facilities where exposed thermally energetic materials are handled which have a high probability of ignition and a large thermal output as indicated by hazard assessments performed in compliance with paragraph 13.2,

a fire detection and extinguishing system which is sufficiently quick-acting and of adequate capacity to extinguish potential flash fires in their incipient stage will protect both workers and property. Design and installation of the system must maximize speed of detection and application of the extinguishing agent.

d. In ammunition operational areas where it is essential for workers to be present, and the hazard assessment indicates an in-process thermal hazard exists, use of thermal shielding between the thermal source and the worker is an acceptable means of protection. If shields are used, they should comply with MIL-STD-398. If shielding is not possible, or if that provided is inadequate for protection of exposed personnel including their respiratory and circulatory systems, augmentation with improved facility engineering design, personnel protective clothing and equipment may be necessary.

e. Thermal protective clothing must be capable of limiting bodily injury to first degree burns (0.3 calories per square centimeter per second with personnel taking turning evasive action) when the maximum quantity of combustible material used in the operation is ignited.

f. Protective clothing selected must be capable of providing respiratory protection from the inhalation of hot vapors and toxicological effects when the hazard assessment indicates adverse effects would be encountered from the inhalation of combustion products.

CHAPTER 14

CHEMICAL AGENT STANDARDS

14-1 SCOPE AND APPLICABILITY

A. This chapter sets forth standards for protecting workers and the general public from the harmful effects of chemical agents associated in research, testing, training, laboratories, manufacturing plants, preservation and maintenance operations, storage, demilitarization and other DOD component agent operations. They apply to mustards: H/HD - 2,2' dichlorodiethyl sulfide, H/HT - 60% HD and 40% 2,2' dichloroethylthiodiethyl ether, L - dichloro (2-chlorovinyl) arsine; and to nerve agents: GB - isopropyl methylphosphonofluoridate, VX - O-ethyl S-[2-(diisopropylamino) ethyl]methylphosphonothioate, and GD - pinacolyl methylphosophonofluoridate; or to mixtures of these agents.

B. Ammunition containing chemical agents may present additional hazards of blast, fragments, and thermal effects. Standards relating to explosives hazards are addressed in other chapters and are applicable herein.

C. Permissible Exposure Limits (PEL) herein (established by The Army Surgeon General) are maximum permissible exposure. Every effort must be made to maintain exposure as low as technically feasible.

D. Engineering controls will be used and tested to provide safe conditions for chemical agents under research and development until such time that PELs are established by The Army Surgeon General or until relative toxicities are determined and documented to show there is a reduced need for such engineering control. The PEL will be established prior to bulk agent manufacture and prior to the use of the agent as an agent fill in ammunition.

E. This standard does not apply to situations where the immediate disposal or detoxification of chemical ammunition or chemical agents is necessitated by an emergency when delay would clearly cause a greater danger to human life or health.

F. DOD Components are responsible for developing implementing standards and safety procedures for logistical movements, training, and field operations. To the maximum extent practicable, the standards for PEL, exposure controls, and measurements contained herein will be followed.

G. Personnel directly involved in military training with chemical agents may use standard field issue types of military equipment and protective clothing.

H. For commercially available agents or for incapacitating agents in munitions awaiting demilitarization (e.g., BZ, CL, CG, CK, AC), requirements of DODI 6055.1, "DOD Occupational Safety and Health Program," apply.

I. The use of DODI 5000.36, "System Safety Engineering and Management (MRA&L)" and MIL STD 882A, "System Safety Program Requirements," will be followed.

14-2 PERMISSIBLE EXPOSURE LIMITS

A. Defense Installation Permissible Exposure Limits

1. Hazard Zone Calculations

Because of the diversity of agents which may be present at an installation, and the wide variation in hazards associated with maximum credible events (MCE), individual calculations must be made for each agent. It will be necessary to hypothesize a MCE to enable calculation on the extent of the hazard zone. For agent-filled ammunition without explosives, the MCE factors shall include the number of items likely to be involved, the quantity of agent released and the percentage of that quantity which would be disseminated. For ammunition with explosives components, the MCE will be based on a detonation of the explosive components which would produce the worst results regarding release of agent. The propagation characteristics of the ammunition will be considered in developing the overall MCE. The amount of agent released and the nature of release (evaporation or aerosolization) as a result of MCE will then be used to make the hazard-zone calculations required by this standard. Hazard

zone calculations will conform with DDESB Technical Paper No. 10, Methodology for Chemical Hazard Prediction, June 1980.

2. Installation Siting Limits

The hazard zone calculated from the MCE shall represent that arc from the agent source containing a dose of no more than 10.0, 4.3, and 150.0 mg-min/m^3 of GB, VX, or mustards respectively and 0.1 mg for inhalation-deposition of VX. Positive means shall be taken to ensure that personnel, not directly associated with chemical weapons operations, enter such areas as defined. Positive means shall include written procedures which may be reviwed and updated as necessary. Positive control of an area, which can ensure that personnel can evacuate or be protected prior to exposure in the case of an MCE may be developed in lieu of absolute exclusion. Details of such control procedures must be included in the Site and General Construction Plans Review (para 3-6).

3. Planned Agent Releases

In cases where, by the nature of the operation, a release of agent is expected (such as in the case of testing, destruction, training or certain preventive maintenance operations), calculations will assure that non-related personnel are protected (minimum) to the "no-effects" level (i.e., no more than 0.5, 0.4 and 2.0 mg-min/m^3 for GB, VX and H, HD respectively and 0.011 mg for inhalation-deposition of VX).

B. Workplace Permissible Exposure Limits

PELs for each chemical agent are listed in Table 14-2.1. Time weighted averages (TWA) are the exposure limitations imposed, averaged over any work shift, on unprotected personnel. Control and ceiling values are limitations on the environmental concentrations of chemical agents which can be allowed to reach unprotected people.

14-3 AGENT EXPOSURE CONTROL AND MEASUREMENT

A. Initial Hazard Analysis and Exposure Measurement

1. A job hazard analysis will be conducted for all new operations involving chemical agents or whenever there is a change in production, process, or control measures which could result in an increase in airborne or contact concentrations of chemical agents.

2. A written record of the initial hazard analysis will be made and retained as a permanent record. As a minimum, the following information will be included:

a. Date of initial hazard analysis.

b. Work being performed at the time, locations within the work site and workers considered.

c. Information, observations or calculations which may indicate worker exposure to chemical agents.

d. Measurements of chemical agent concentrations determined.

e. Worker complaints of symptoms which may be attributable to exposure to chemical agents.

3. If it is determined that any operation may expose workers to chemical agents above the PEL, procedures will be established so that the actual exposure will be measured. Each measurement must be representative of the maximum eight-hour time weighted average exposure of the worker. If the measurement reveals workers may be exposed above the Action Levels, their exposure will be measured for the duration of the work period.

Table 14-2.1 Permissible Exposure Limits

Exposure	CHEMICAL AGENTS Mg/m^3 GD	GB[c]	VX[c]	H&HD[c]	L	Exposure time
Unmasked Worker						
Time Weighted Average	b	0.001	0.00005	b	b	1-hr ave.
	b	0.0003	0.00002	b	b	8-hr ave.
	b	0.0001	0.00001[a]	0.003[a]	b	8-hr/day, indefinitely
	b	b	b	0.3	b	6-min ave.
	b	b	b	0.01	b	3-hr ave.
Ceiling Value	b	b	b	0.4	b	
General Population						
Time Weighted Average	b	0.0001	0.00001	b	b	1-hr ave.
	b	0.000003	0.0000003	b	b	72-hr ave.
	b	b	b	0.00033	b	3-hr ave.
	b	b	b	0.00017	b	8-hr ave.
	b	b	b	0.0001	b	72-hr maximum ave. time, indefinitely
Ceiling Value	b	b	b	0.01	b	
Source Emission Limit	b	0.0003	0.00003	0.03	b	1-hr ave.

a. Averaged over not more than five, 8-hour periods per 40 hours work week.

b. The Army Surgeon General has been requested to provide this value. Until the values are available from the Surgeon General, strict engineering controls are required. The subject agent must be controlled as a new agent in the absence of the value.

c. The Army Surgeon General is updating exposure control limits for these agents. When formally promulgated, updated exposure control limits shall supersede the limits shown in the table. DDESB has also requested The Army Surgeon General to provide PELs for agent liquid and solid contamination.

4. If an exposure measurement reveals that a worker is exposed to chemical agent above the Action Level, but not above the PEL, or ceiling, the exposure of that worker will be measured at intervals not exceeding three (3) months.

5. If an exposure measurement reveals that workers will be exposed to chemical agents above the PEL, their exposure will be measured continuously and control measures required by paragraphs 14-3C, 14-6 and 14-7 will be instituted. Every worker who is found to have been exposed to chemical agents above the PEL will be notified, in writing, within 5 days by the DOD Installation Commander of the results of the exposure measurements and corrective action being taken to reduce the exposure to a level below the PEL.

6. Special exposure measurements will be made when the values exceed the specified limits. If two consecutive special exposure measurements taken at least one week apart reveal that the worker has been exposed to chemical agents below the Action Level, special measurements may be terminated. If two consecutive special exposure measurements taken at least one week apart reveal that the worker has been exposed to chemical agents above the Action Level, but below the PELs, exposure measurements as prescribed in paragraph 14-3A4 will be resumed.

B. Methods of Measurement

Devices for sampling and analyzing workplace air should measure and alarm on a real-time basis when chemical agents are present in excess of the PELs. Until real-time area detectors, alarms and dosimeters with such sensitivity are available, engineering controls, continuous point-source agent detector- alarms or dosimeters and/or agent protective clothing will be used.

C. Exposure Control

1. When exhaust systems are used to control exposure, measurements of system effectiveness (such as air velocity or static pressure) shall be made at least every three (3) months or prior to initiation of operations with any

change in production, process or control.

2. Prior to commencing chemical agent operations, a determination will be made that the hazard zone associated with those operations is under positive control IAW paragraph 14-2A2. In the event conditions exist that extend this zone off-post or to non-related on-post personnel, restrictions (operational, containment, meteorological, or other) will be placed on the operations to assure compliance with paragraph 14-2A2.

3. Control of accidental agent release will be in accordance with guidance provided in paragraph 14-2A2.

4. In the absence of these controls, personnel will be protected by the use of respirators which are specifically approved (Health standards allow only respirators approved by Bureau of Mines, i.e., Mining Enforcement and Safety Administration, MESA, and NIOSH under 30 CFR 11) and which meet the technical requirements specified by 30 CFT part 11.

Table 14-3.1. Dosimeter, Detection, and Alarm Devices for Agents GB, VX, and Mustards

AGENT	DEVICE	USAGE: INDOOR	USAGE: OUTDOOR	SENSITIVITY	RESPONSE TIME	FLOW REQUIREMENTS: AIR	FLOW REQUIREMENTS: WATER	DETECTION AREA: POINT SOURCE	DETECTION AREA: AREA	AVAILABILITY
GB	Detectors/Alarms:									
	M43 Detector	X	X	0.2 mg/m^3	1 min	1 l/min	NA	X	-	Army Stock
	M43A1 Detector	X	X	0.2 mg/m^3	3-4 sec	1 l/min	NA	X	-	1st Prod CY83
	Real Time Monitor	X	-	0.0001 mg/m^3	12 min	10 l/min	NA	X	-	Special Order
	*Agent - Conc/Detector	X	-	0.001 mg/m^3	33 min	6 l/min	NA	X	-	Special Order
	Dosimeter/Personnel	X	X	0.0001 mg/m^3	447 min Total 357 min sampling 90 min transport & analysis	30 cc/min	NA	X		Special Order
	**ACAMS	X		.0001 mg/m^3	15 min	250 cc/min	NA	X		Special Order
	Bubblers	X	X	0.0001 mg/m^3	150 min total 60 min samp + 90 min anal	2 l/min	NA	X	-	Army Stock
	Kits:									
	M256 Kit	X	X	0.02 mg/m^3	15 min	(Static 10 min samples)	NA	X	-	Army Stock
	***M18 Kit	X	X	0.02 mg/m^3	10 min	1 liter	NA	X	-	Army Stock
	M30A1 Kit	X	X	0.05 mg/m^3	1-2 min	1 liter	NA	X	-	Army Stock
	AN-M2 Water Test	X	X	4.0 ppm	15 min	NA	25 ml	X	-	Army Stock
VX	Detectors/Alarms:									
	M43 Detector	X	X	0.4 mg/m^3	3-4 min	1 l/min	NA	X	-	Army Stock
	M43A1 Detector	X	X	0.4 mg/m^3	3-4 min	1 l/min	NA	X	-	1st Prod CY83

* Concentrator w/Detector - Concentrator portion samples at a rate of 6 l/min; the sensor portion (M43 Detector) always samples at a rate of 1 l/min.
** Automatic Continuous Air Monitoring System
*** Response Time For Individual Agent Test Operations

Table III-3.1. Dosimeter, Detection, and Alarm Devices for Agents GB, VX, and Mustards

AGENT	DEVICE	USAGE		SENSITIVITY	RESPONSE TIME	FLOW REQUIREMENTS		DETECTION AREA		AVAILABILITY
		INDOOR	OUTDOOR			AIR	WATER	POINT SOURCE	AREA	
	Real Time Monitor	X	-	0.00001 mg/m^3	12 min	10 l/min	NA	X	-	Special Order
	Bubblers	X	X	0.00001 mg/m^3	330 min Total 240 min Samp + 90 min anal	2 l/min	NA	X	-	Army Stock
	Kits:									
	M256 Kit	X	X	0.04 mg/m^3	15 min	Static (10 min sample)	NA	X	-	Army Stock
	*M18 Kit	X	X	0.04 mg/m^3	10 min	1 liter	NA	X	-	Army Stock
	M30A1 Kit	X	X	0.05 mg/m^3	1-2 min	1 liter	NA	X	-	Army Stock
	AN-M2 Water Test	X	X	4.0 ppm	15 min	NA	25 ml	X	-	Army Stock
Mustard	Detectors/Alarms:									
	**ACAMS	X		0.003 mg/m^3	15 min	250 cc/min		X		Special Order
	Bubblers	X	X	0.003 mg/m^3	210 min Total 120 min Samp + 90 min anal	6 l/min	NA	X		Army Stock
	Kits:									
	M256 Kit	X	X	2.0 mg/m^3	15 min	Static (10 min sample)	NA	X		Army Stock
	*M18 Kit	X	X	.5 mg/m^3	5 min	1 liter	NA	X		Army Stock
	AN-M2 Kit	X	X	5.0 ppm	15 min	NA	3 ml	X		Army Stock

* Response Time For Individual Agent Test Operations
** Automatic Continuous Air Monitoring System

14-4 MEDICAL SURVEILLANCE

A. Preassignment, periodic and/or annual health assessments will be provided for each worker to establish a base-line health record and to provide counseling on health matters as related to the chemical agent operations. In addition to the preassignment, periodic and annual health assessments, the medical surveillance program will include a work history, a medical history, physical examinations, indicated laboratory studies and when available, examinations or tests specific to the agent(s) in question. The DOD Component shall provide a procedure for notification when off-duty symptoms develop from agent exposures. The DOD Component shall also provide relevant information to the physician about the employees potential agent exposures and duties and the physician will provide the DOD Component with his written opinion on the employee's fitness for duty.

B. The military departments Surgeon Generals will provide guidance to installation commanders for selecting DOD Medical Officers from each installation for specialized training. This training will emphasize the unique hazards of agents and the required treatment specific to casualties from agent exposure. If practical, the training program should include limited observations of a medical program implemented at a DOD installation with an extensive storage and demilitarization mission.

14-5 WORKER PROTECTIVE CLOTHING AND EQUIPMENT

A. Where practicable, positive engineering and administrative controls, such as remote operations, ventilation, isolation, substitution of materials, limitation of the quantity of hazardous materials and the number and time of operator involvement will be incorporated in all operations involving chemical agents to preclude or minimize the need for personal protective clothing.

These protective measures must insure that the worker can escape after accidental agent release without suffering health damage. Examples of situations where operational/emergency protective clothing and equipment may be required are:

1. Hands-on transfer, compounding, or other handling of agents within a primary containment facility such as a laboratory exhaust hood or glove box requires hand, face, body and respiratory protective equipment in combination dependent on the type, quantity and dynamics of the operation. The type of clothing also takes into consideration the protection required for agent release abatement or decontamination when an emergency occurs and evacuation from the area is necessary.

2. Where persons work in an area that may become hazardous in case of system/procedural failure.

3. Where agents are stored or transported outside a containment facility.

B. Agent contaminated personal protective clothing and equipment will be detoxified to a level that is safe for re-use or, in the case of disposed material, safe for routine disposal. This detoxification level will be verified by analytical testing. Procedures will also be established to assure personal protective clothing is properly sanitized.

C. The DOD Component will establish acceptance and in-life test programs to assure that the chemical agent protective clothing and equipment will, when properly worn and maintained, prevent occupational exposure in excess of Table 14-2.1 PELs and to percutaneous exposure for the maximum time the clothing/equipment will be worn.

D. Respiratory Protective Equipment. The respiratory protection program will be established in conformance with 29 CFR 1910.134. See 14-3.C4 for the approved respirator requirements.

The breathable air supply to which protective equipment and clothing are connected must conform to or exceed the requirements for Grade D air as given in the Compressed Gas Association's Commodity Specification, G-7.1 1973 or equivalent DOD Component Systems.

E. Percutaneous Protection Clothing. In DOD operations such as manufacturing, training (see 14-1H for exception), depot maintenance, surveillance, demilitarization and storage. The worker will use protective clothing for percutaneous protection. This protective clothing could be a full body enclosure, which completely encapsulates the wearer, including the hands, feet and head. Ancillary equipment includes toxicological agent protective butyl rubber boots and gloves, and communication equipment.

14-6 ADMINISTRATIVE AND WORK PRACTICE CONTROLS

A. Containment Controls

1. Certain agent/ammunition operations are inherently hazardous and appropriate control of the hazards involved is necessary, not only for the protection of persons performing such work, but also other persons both inside and outside the installation. Containment is the principal control measure for prevention of exposure of personnel to agents.

2. There are two types of containment: "total containment," and "vapor containment." Whenever used, each must incorporate effective means for

entrapping or detoxifying the evaporated or aerosolized agent (e.g., filters, scrubbers and incinerators.)

a. Total containment requires the equipment/facility to be of a tested design capable of containing all the reaction gases, detectable agent and fragments from the largest explosion that could occur without causing equipment/facility rupture or leakage.

b. Vapor containment requires the equipment/facility to be of a tested design capable of containing non-explosion releases of agent. Commonly used design features include negative pressure, controlled air flow and single or multiple walled enclosures which will prevent accidental release of any detectable quantities of agent. Designs for vapor containment are usually tailored to the operation involved.

3. The selection of the type of containment is dependent upon the nature of the operation involved. Total containment is required for those operations involving ammunition which contain explosive components as well as agents, wherever the operation may subject the explosive components to a potential initiating stimulus. Vapor containment is required for those operations involving agents in bulk or in ammunition without explosives components and for those operations involving ammunition containing both agent and explosive components that do not subject the explosive components to a potential initiating stimulus.

a. Operations requiring total containment include:

(1) Chemical ammunition, cutting, sawing, milling, drilling, punching or shearing operations that require the machine tool to remove or displace metal before or after contact with the explosives.

(2) Operations in which the ammunition arming and functioning environments can be duplicated by the equipment or process.

(3) Disassembly of armed or possibly armed ammunition.

(4) Disassembly of explosive components from ammunition that requires application of significantly greater leverage or torque than that required for assembly.

b. Operations requiring vapor containment are:

(1) Chemical ammunition, punching, drilling, or sawing operations for removal of agent that use equipment designed to prevent contact of the cutting tool with explosives.

(2) Burster well removal, after removal of explosive components.

(3) Transfer of agent from bulk storage tanks, containers, or ammunition into holding tanks, chemical detoxification reactors, incinerators, or similar processing equipment, such as may be found in a production, demilitarization or disposal line. This is not to be construed as requiring vapor containment for agent transfer during field operations involving leaker repair activities.

4. Containment is not required for operations associated with field storage and maintenance activities (e.g., shipping, storing, receiving, rewarehousing, minor maintenance, surveillance inspection, repair, and encapsulation). Emergency agent transfer in the event of leakage is also permitted without containment. In the event of a leaker, measures such as personal protective clothing and the type C positive pressure full face piece respirator with an auxiliary self-contained provision are mandatory to protect operating personnel during the decontamination or detoxification of the escaping agent, and during repair, encapsulation, or transfer of agent from the leaking ammunition or container.

B. Training and Information

All who work directly with chemical agents and ammunition will receive sufficient training to enable them to work safely and to understand the relative significance of agent exposures. This training shall include information on sources of exposure, possible adverse health effects, practices and controls being used to limit exposures, environmental and medical monitoring procedures in use and their purposes and worker responsibilities in health protection programs.

C. Record Keeping

Record keeping pertaining to exposure determination and measurement, mechanical ventilation, employee training, medical surveillance and access to records shall be consistent with DODI 6055.5 requirements.

D. Labeling and Posting of Hazards

1. Signs and labels to warn employees on hazards of chemical agents are required for work areas, for containers of chemical agents, worker contaminated clothing and equipment, and for identification of restricted use areas.

2. Where opportunity for agent contamination exists, buildings, equipment, tools or other items will be marked or tagged to indicate degree of decontamination undergone or that the facility or item has never been exposed to chemical agents whichever is appropriate. An agent symbol with a single "X" indicates the item has been partially decontaminated of the indicated agent. Further decontamination processes are required before item is moved or any maintenance, repair, etc., is performed without the use of chemical protective clothing and equipment. This degree would generally be applied to the item as it stands in place after being used and subjected only to routine cleaning after use. An agent symbol with three "Xs" indicates that an item has been examined

and cleaned by approved procedures and no agent contamination above 0.0001, 0.00001, and 0.003 milligrams per cubic meter of GB, VX, or mustard, respectively can be detected by appropriate instrumentation (Table 14-3.1). This item is then considered safe for its intended use only. An agent symbol with five "Xs" indicates an item has been completely decontaminated of the indicated agent and may be released for general use or sold to the general public. An item is completely decontaminated when the item has been subjected to procedures which are known to completely degrade the agent molecule.

E. Emergencies

1. In case of accidental release of agent that may result in personnel exposure, all affected areas will be evacuated immediately and emergency procedures started. The cause of the release will be eliminated and affected areas monitored and decontaminated, as appropriate, to applicable Table 14-2.1 PELs before normal operations are resumed.

2. Special medical surveillance must be started within 24 hours for all workers present in the potentially affected area at the time of the emergency. Any worker known to have contact with the chemical agent must use appropriate decontamination materials and receive medical treatment on an expedited basis.

3. The DOD Component will maintain up-to-date chemical accident and incident control plans and will conduct periodic practice exercises of these plans.

F. Maintenance Controls

1. A continuing program for equipment and facility maintenance will be implemented for all chemical agent operations.

2. If possible, the chemical agent process should be shut down and decontaminated prior to maintenance, testing, or repair operations.

G. Fire Safety Controls

In addition to training provided for agent workers, fire protection workers shall be familiar with the contents of the following references:

1. "Agent Safety Data Sheets" (identification, health hazard data, emergency first-aid procedures, detailed information on the respirator and the complete percutaneous protective clothing, precautions for safe use, handling, and storage, and access to information).

2. "Agent Technical Guidelines" (physical-chemical data, fire, explosion and reactivity hazard data, spill, leak and disposal procedures; monitoring and measurement procedures, miscellaneous precautions and common operations); and

3. "Medical Surveillance Guidelines" (agent route of entry, toxicology, signs and symptoms, special tests, treatment, surveillance, preventive considerations, and periodic examinations).

H. Spills and Disposal Controls

When chemical agents are spilled or released, maximum ventilation will be provided immediately, the agent will be detoxified, and the spill area will be cleaned. Wastes must be retained within the facility sump until tests confirm that agent present in the wastes do not exceed applicable Table 14-2.1 PELs. In outside agent work-storage areas where spills occur, the immediate area will be chemical agent detoxified. After detoxification, the surface soil layer will be removed to a depth where PELs are not exceeded and this soil processed through an approved incinerator.

I. Chemical Agent Detoxification

1. When protective clothing becomes contaminated with chemical agents, the outside layer of clothing will be removed as soon as practicable and be detoxified and rinsed with water.

2. Prior to leaving work areas, the outer surfaces of the outer garments, and the protective boots and gloves will be detoxified and rinsed with water. The protective clothing must be certified prior to reuse (see para 14-6J). The workers may exit the chemical agent operational area using the "buddy-system." The respiratory protective system will be worn until the workers arrive at a site location certified to be free of agent.

3. Any protective clothing which retains agent after decontamination, i.e., exceeds the Table 14-2.1 PELs established, will be condemned and incinerated. Standard issue field protective clothing used for military personnel training can be reissued as long as detectable agent satisfies The Surgeon General's exposure level criteria.

J. Recertification of Percutaneous Protective Clothing

1. The reusable outer protective garment must be placed in an agent tight container after decontamination and the container inner atmosphere tested for agent. The used protective garment will be so held in isolation until test results are available. If the tests results indicate the agent contamination level does not exceed Table 14-2.1 PELs, the garment may be laundered, visually examined, and recertified by the DOD Component for use. Other items of toxicological agent protective clothing, e.g., boots and gloves, will be tested, laundered and recertified for use in the same manner. Items which cannot be certified shall be handled as provided in paragraph 14-6I.

2. All percutaneous protective items will be numbered and records maintained on the agent exposure, name of the user, date of use, and launderings undergone.

K. Storage, Decontamination and Disposal Controls

In addition to the requirements of this Chapter, storage, decontamination and disposal operations should consider the principles of 40 CFR Parts 264 and 265 under Section 3004 of the Resource Conservation and Recovery

Act of 1976 as amended. Facilities will be periodically monitored for accumulation of agent contamination both in air and on surfaces. Routine decontamination of work surfaces known to be agent contaminated will be accomplished at least on a weekly basis. When indicated by monitoring procedures or in the event of an agent spill, additional decontamination will be required. Routine air monitoring including below surface liquid waste systems will be performed continuously during agent operations and on a quarterly basis in the absence of active agent operations. Facility surface samples also will be collected and analyzed using the same time intervals.

L. Transportation of Materials Contaminated with Chemical Agents

Materials contaminated with chemical agents may be transported from one location to another. The material must be encapsulated so that the concentration of agent on the outside of the encapsulating material does not exceed Table 14-2.1 PELs. The limits established for unmasked workers are applicable for transportation on non-DOD controlled property. The encapsulating material must be resistant to agent penetration, retention and of sufficient strength to resist damage during the move that could result in agent release. Laws and regulations of federal/state governments (or other nations) concerning the transportation of hazardous materials must be complied with.

M. Transportation of Bulk Agents and Chemical Ammunition

The requirements established by AR 740-32, OPNAVINST 8070.1B, AFR 136-4 and MCO 4030.25B, "Responsibilities for Technical Escort of Dangerous Materials" will be satisfied.

14-7 ENGINEERING DESIGN CRITERIA FOR FACILITIES

Minimum engineering design criteria are herein set forth for facilities that are used for handling, storage, maintenance, surveillance, transportation, training, testing, research, disposal and demilitarization of chemical agents/-ammunition. Support areas for these operations and for operations personnel are included. Other design criteria that affords the same degree of safety can be used.

A. Air Ventilation Systems

Air handling systems will be designed to ensure that control of agent-contaminated exhaust will not exceed the Table 14.4.1 PELs. In operations requiring air ventilation systems, the following techniques can be used.

1. Filters and/or scrubbers for exhausted air will be designed and approved for the "maximum credible event" (MCE) of the operations involved. Changes in the agent operations within a facility require that the design of the existing filter be evaluated for adequacy in terms of the new MCE. Where a single filter and/or scrubbers are employed, a gas life indicator or another suitable method to predict filter life will be used to allow filter change-out before the Table 14-2.1 PELs are exceeded. When high concentrations of agent are involved and break-through of agent can be expected, pre-processing through a series of scrubbers or use of redundant filters will be employed. High efficiency particulate air filters will also be used in the air ventilation systems. Each filter bank will be provided with a means to measure differential pressures across each bank of filters. In larger facilities, ducting and manually operated dampers will be provided for back-up exhaust ventilation capability. Filter disposal will be accomplished by placing the used filter in an agent-tight package, transporting the package, (14-6L 14-6M), to an approved incinerator designed so that Table 14-2.1 PELs, during and after destruction are not exceeded, and the whole package incinerated.

2. The air carrying system, e.g., ductwork, stacks, blower housing, will be sealed to preclude leakage or entrapment of agents exceeding Table 14-2.1 PELs.

3. All exhaust equipment will have back-up blowers which automatically engage should the main blower fail. The back-up blowers will assure a negative pressure is maintained at all times in any facility area where there is a potential for chemical agent to be released.

4. The air flow for laboratory exhaust hoods and glove boxes will be designed to contain agents below Table 14-2.1 PELs for unprotected workers. The design parameters will consider equipment and process layout, make-up air flow and operational positions with regard to maintaining flow balance and cross currents. The system will maintain negative pressure in operating areas in relation to hallways, offices, and other non-agent areas. Glove boxes will be used when the hazards analysis indicates that the toxicity, dusting or dispersion of material caused by air flow, and type of operation require such protection.

5. The minimum acceptable hood face velocity must be 0.3 meters/second (60 FPM) when the hood is installed in draft-free rooms. Performance of the chemical hood is affected by air flow within the facility as well as hood geometry, design and operating parameters. During operations, chemical agents must be kept at least 20 centimeters inside the hood sash. The adequacy of performance will be determined periodically using quantitative tracer gas tests. This may be augmented by using visible smoke candles and other tests to assure proper functioning of delta pressure and other flow indicators.

6. Catch basins and traps of suitable size will be provided within hoods and glove boxes.

7. Special design features shall be used where exposed explosives are involved to segregate explosives from air ventilation systems.

B. Mechanical and Utilities Design for Facilities

A concept of agent contamination avoidance and control will be incorporated and included with the facility lay-out and design.

1. Working surfaces, e.g., walls, floors, and ceilings, within a facility likely to be agent contaminated during regular or accidental situations will be constructed of materials for which test results indicate the surface

treatment is resistant to agent retention and/or the surface treatment shall have properties incorporated to accelerate agent degradation; or the surface can at least be decontaminated to the PEL for unprotected workers. Flooring will be coved six inches onto all wall surfaces. Floor surfaces will be treated and seams sealed to contain and control agent contamination and facilitate agent cleanup.

2. Utilities, mechanical rooms, and other non-agent areas will be located so that air flows toward agent operating areas. Access to these non-agent areas shall be accomplished without entry into agent areas.

3. The electrical system will be equipped with a back-up power source designed to start automatically and supply sufficient power to support critical functions in the event of power outage. Wiring, controls, lightning protection and other electrical devices will meet requirements of the National Electrical Code for the applicable hazardous operational facility.

4. Safety showers and eye-wash fountains will be provided and so located that a worker will have immediate access in case of emergencies.

5. All water outlets in the agent operational facility will be fitted with vacuum breakers to prevent backflow of water into the service lines. Special design features shall be used where exposed explosives are involved to segregate explosives from drain lines and sumps.

6. Dedicated liquid waste systems will be designed to collect and maintain the effluent produced by the activity until processsed and certified to meet the Table 14-2.1 PELs required for release. The system will be equipped with a means to sample and test the agent content of the effluent, to add required agent-decontaminant and to release the wastes when authorized. Vents or other openings in the waste system will be fitted with approved agent filters. A containment dike designed to hold the total content of the waste

system plus 10% of the volume will be placed around aboveground liquid waste systems.

7. Decontamination facilities of sufficient capacity to catch and contain the effluent will be provided for agents involved. Decontaminated effluents will be certified not to exceed Table 14-2.1 PELs or they will be held by an approved containment procedure. Decontamination solution will be immediately available for use on personnel or on facilities in event of an agent accident. Ammunition drained of agent and chemically decontaminated should be processed through approved agent-destruction incinerators prior to release.

8. Where operations require work assignments to be conducted at exposure levels above or potentially above the PEL for unprotected workers, change facilities with showers will be provided. Upon exiting the agent operational area and before entering the change facility, the protective clothing is removed, bagged, heat equilibrated at 70°F and the interior atmosphere of the bag tested for agent. The test results must indicate that the applicable Table 14-2.1 PELs are not exceeded prior to re-issue or laundering of the protective clothing.

C. General Design Considerations

1. Facility Alarms and Monitors for Engineering Systems

Each chemical facility will have a master alarm and control panel which will permit functional verification of the exhaust blowers, back-up blowers, air conditioning units, fire control systems, waste treatment, agent and chemical storage areas and exhaust filters. Keyed to this master alarm panel will be visual and audible alert alarms to instantly indicate failure of exhaust blowers, agent break-through of primary filter, back-up blowers, fire alarm (infrared, ultra violet, ionization, or particulate activated sensors) field waste pump failure and temperature increases in low temperature storage areas. Alarms will be incorporated for use in the work areas when injury or

accidents occur in the facility. Except for static storage operations, all facility alarm systems for dynamic operations will be monitored consistent with operational requirements. In the absence of monitoring, first entry monitoring procedures are required.

2. Fire Detection and Protection. Fire detection and protection systems for production and maintenance facilities will comply with the requirements and guidelines published in "Engineering Guide for Fire Protection and Detection Systems of Army Ammunition Plants - Volume I, Selection and Design," ARLCD-CR-80049, December 1980.

3. Bulk Storage Tanks. Dikes which are impermeable to agent penetration and of sufficient capacity to hold at least 110 percent of the tank capacity and the required volume of decontaminant solution, will be placed around all bulk agent tanks, reactors, mixers, etc. Underground vaults which contain bulk storage tanks will be supplied with connections for breathing/quality air compatible with the protective clothing hardware unless self-contained protective clothing including the positive pressure full face piece respirator with an auxiliary self-contained provision.

4. Isolation of Facility Functions. The agent facilities will be designed to isolate one activity from another activity in an independent and completely autonomous manner. Special design criteria shall segregate explosives from drain lines and sumps to prohibit deposition of explosives materials in these process units.

5. Monitoring. Monitoring stations will be established around chemical operational areas and facilities to monitor the air and liquid waste effluents and alarm when Table 14-2.1 PELs or thresholds are exceeded.

6. Agent Operational Areas. The chemical handling and maintenance areas associated with industrial operations are to be isolated from the main facility by protective walls and doors, and are operated at a negative pressure

with respect to the main facility area. All hazardous materials will be handled in these rooms unless a glove box is required. The handling rooms will be equipped with local exhaust ventilation and approved work surfaces which inhibit agent penetration and retention, and other means to minimize the spread of contamination. All air leaving the facility will be filtered or decontaminated before release to the atmosphere. The flow of ventilation (negative pressures) should go from less hazardous to more hazardous as based upon agent concentrations. Appropriate containment (14-6.1) facilities will be used as necessary during ammunition maintenance procedures.

7. Utility Area. Electrical control panels, hot water heater and vacuum pump will be located in a utility area. Compressed air, argon, nitrogen, etc. will be supplied to the facility from gas bottle manifolds. Where air-supplied protective clothing and equipment is used, breathing quality air will be provided with suitable connections throughout the facility (14-5D). The waste liquid treatment area and the emergency auxiliary power will be located in the facility complex. Appropriate access to all plumbing, electrical conduits and relays, refrigeration equipment and air handling equipment will be incorporated. Supply and exhaust blowers for the laboratory exhaust hoods, the exhaust air purification system and cooling equipment will be located at ground level.

8. Viewing of Operations. A valuable asset in the industrial facility design is to provide for visual observation of virtually all work spaces by a viewing hall. A clear view of the laboratory exhaust hood workrooms, main laboratory rooms, storage areas and safety shower area is possible by selection of the appropriate design.